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Cheilostomata of the Gulfian Cretaceous of Southwestern Arkansas.

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CHEILOSTOMATA OF THE GULFIAN CRETACEOUS OF SOUTHWESTERN ARKANSAS

A Dissertation

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ABSTRACT

Cheilostome Bryozoa, collected by detailed sampling in Upper Cretaceous (Gulfian) rocks in southwestern Arkansas, were studied taxonomically and compared with their counterparts from other North American and European Cretaceous and Paleocene rocks. Many specimens, most of them poorly preserved, were found sporadically distributed through the Brownstown, Ozan, Saratoga, and Nacatoch formations, and most abundantly in biostromal pelecypod accumulations. The abundant occurrences seem to represent shoal-water habitats, and most of the specimens are incrusting upon pelecypod valves.

The Arkansas occurrences represent the Santonian to upper Maastrichtian European stages. The concurrence of ranges of similar species on the two sides of the Atlantic is striking. The major change in Cheilostome faunas at the base of the Campanian in Europe is reflected in the Arkansas cheilostomes, especially in the first appearance of ascophorans. Several genera have synchronous ranges, and one (Cheethamia) is a stage index.

The generic ratio, Anasca: Acanthostega: Ascophora, follows similar trends in Arkansas and Europe, with the Anasca retaining dominance throughout the Cretaceous. Maximum diversity was attained in Maastrichtian time in both Europe and Arkansas.

In this paper 22 species of Cheilostomata are described from the Arkansas Gulfian Cretaceous. Two new genera, Cheethamia and Stictostega, and 16 new species, Pyripora brownstownensis, Ellisina saratogaensis, Alderina inuber, Ramphonotus pedunculatus, Solenophragma elongatum, Dionella vivistratensis, Dionella racemata, Cheethamia howei, Aechmella ozanensis, Tricephalopora larwoodi, T. arkansasensis, Diacanthopora langi, Escharoides ? danei, E. ? nomas, E. ? erymnos and Stictostega durhami are described. Frurionella parvipora Canu and Bassler, Solenophragma ovatum (Canu and Bassler), and Castanopora spooneri (Butler and Cheetham) are redescribed. Three species, Solenophragma sp., Micropora ? sp., and Escharoides ? sp., were left nomina aperta.

INTRODUCTION

This paper presents the results of a taxonomic study of cheilostome bryozoans from the exposed Gulfian Cretaceous strata of southwestern Arkansas, a comparison with their counterparts in Europe and in other parts of the Eastern North American Coastal Province, and an evaluation of their stratigraphic distribution and paleoecology.

Although many investigations have been made of the stratigraphy of the Arkansas Cretaceous formations and Carle H. Dane (1929, p. 109, 132) in his classic work recorded the presence of Bryozoa in the Saratoga Chalk and Nacatoch Sandstone, their taxonomy and distribution have never been studied. In fact, few papers have been published on North American Cretaceous Bryozoa (Canu and Bassler, 1926; Cheetham, 1954; Thomas and Larwood, 1956, 1960; Butler and Cheetham, 1958a, 1958b; Laughbaum, 1959; Toots and Cutler, 1962). The disparity between European and American research efforts has been cited by Butler and Cheetham (1958a).

Undoubtedly, the reason Cretaceous Cheilostomata studies

have progressed so far in Europe is a combination of a greater abundance of well-preserved specimens and availability at major museums of extensive collections which were made over the past hundred years or more. In North America, many field collectors have either overlooked or discarded bryozoans in sampling Cretaceous rocks; hence, adequate museum collections of Cretaceous Bryozoa comparable to the Gaster Collection in the British Museum (Natural History), the Brydone Collection in the Sedgwich Museum (Cambridge), or the d'Orbigny Collection in the Museum national d'Histoire naturelle (Paris) do not exist in this country.

A major part of the present investigation was assembling an adequate collection of sufficiently well-preserved specimens for the taxonomic study. A total of 247 identifiable zoaria and zoarial fragments were collected mainly by sorting through valves and fragments of various species of pelecypods contained in biostromal units in the Saratoga Chalk, the Ozan Formation, and the Nacatoch Sandstone; a smaller part of the total was obtained by washing and screening chalky and marly sediments. Thus the distribution of specimens was found to be sporadic, and most beds yielded no Bryozoa.

Poor preservation posed an even more difficult problem. Zoaria are generally small, usually broken, and often masked by chalk, or leached by ground water.

The identifiable specimens have been assigned to 22 species, three previously described, 16 new, and three left nomina aperta (Systematic Descriptions, p. 28). These species are distributed in 15 genera (two of which are new), eight families, and all three known cheilostome suborders. The classification used here follows that of Harmer (1926, 1957), Brown (1952), Lagaaij (1952), and Cheetham (1966); for taxonomy at the generic level, the works of Voigt (1925, 1930, 1949, 1951, 1952, 1957, 1959, 1964), Larwood (1962), and Medd (1965) have been especially useful. Terminology used in the descriptions is the standard one summarized in such works as Brown (1952) and Larwood (1962); measurements follow the practices and notations given by Cheetham (1966).

METHODS OF INVESTIGATION

During three months in the summer of 1961, 262 samples were collected in the field, and additional to the samples hundreds of valves of pelecypods, principally species of Exogyra and Gryphaea, were examined for bryozoan incrustations.

At the outcrop, each lithic unit one inch or more thick was described and sampled. The samples and the pelecypod valves incrusted by Bryozoa were taken to the laboratory and there heated at 400°F. for four hours to remove the moisture, soaked in varsol (Esso solvent) for four hours, immersed in boiling water after the varsol had been poured off, washed over a 150-mesh screen, and dried. This procedure required up to 24 hours for some samples. Loose specimens were then picked from the samples under the stereomicroscope.

Those specimens incrusting large shells not separated by the washing procedure were pried loose with a teasing needle, or in stubborn cases, the shell fragment was trimmed to manageable size with a hammer and small chisel.

Measurements were made with an American Optical Stereomicroscope at a power of 60 X. A conversion factor of 0.0129 mm was used to convert micrometer units to millimeters.

For photography the specimens were blackened with washable ink and passed through the magnesium oxide smoke of burning magnesium strips to obtain the desired contrast. Only in this way was any detail brought out on the poorly preserved material available.

Photographs were taken by L. G. Nichols, Louisiana State University Geology Museum, using a Leitz Ortholux apparatus and Plus-X Pan 120 mm film giving a magnification of 30 X on the negatives. Prints were made to a magnification of 75 X, and none has been retouched.

STRATIGRAPHY

The classical paper on Arkansas Upper Cretaceous stratigraphy by Carle H. Dane (1929) was assembled from numerous analytical observations made by him in the field upon the foundation established by his predecessors, notably R. T. Hill (1888), A. C. Veatch (1906), J. A. Taff (1902), L. W. Stephenson (1928), H. D. Miser (1925), and H. V. Howe (1924). Details of nomenclature and correlation have been reviewed and in some cases changed, especially by Drouant (1959), Thorsen (1959), Collins (1960), and Paulson (1960), but the essential outlines of Dane's stratigraphic column have been followed here.

Equivalence of the exposed Upper Cretaceous formations of Arkansas to European stages is based on correlations made by Stephenson, et al. (1942) using principally ammonites as diagnostic indexes. European stages and zones in figures 5-17 are from Larwood (1962). No attempt is made to revise correlation of Cretaceous formations or groups in North America or between North America and Europe. Correlation charts are used only as a frame of reference for indicating

placement of species of Cheilostomata from Europe and North America in order that their ranges may be compared.

The exposed Upper Cretaceous beds in southwestern Arkansas lie on the southern flank of the Ouachita system at the updip edge of the Gulf coastal plain. Numerous factors (epeirogeny in the Ouachita Province, influx of clastics, changes of sea level) have affected the character of the deposits. The formations consist of sands, shales, silts, marls, limestones and chalks that vary in character from friable sands to indurated limestones.

At the outcrop the resistant beds produce cuestas that have the inface to the north. The dip is usually less than one degree, and the strike varies only slightly from N. 78° E. Many excellent exposures on river banks, highway and railroad cuts, and gulleyed farm lands are easily accessible to the kind of sampling that was undertaken in this study; the localities at which samples were taken are shown on Figure 1.

It is not within the scope of this paper to present detailed stratigraphic descriptions; however, the following summary of Gulfian stratigraphy of southwestern Arkansas is presented as a setting in which to discuss the taxonomy of

the cheilostome Bryozoa.

Woodbine-Eagle Ford Groups

Centerpoint Volcanics

The Woodbine-Eagle Ford equivalents exposed in southwestern Arkansas represent the basal unit of the Upper Cretaceous considered by Stephenson et al. (1942) to be equivalent to the Cenomanian and Turonian of Europe. This unit consists of sand, gravel, clay, and water-laid volcanic sediments named the Centerpoint Volcanics by R. T. Hazard (1939). The average thickness of the Centerpoint Volcanics is approximately 250 feet, but local thicknesses are exceedingly variable. Many of the clay layers contain leaf impressions and carbonized wood. Marine fossils are lacking in Arkansas, but in Texas, Ostrea has been recorded (Dane, 1929, p. 26) from equivalent beds.

Austin Group

Tokio Sandstone

The Tokio Sandstone consists of approximately 345 feet of quartz sand, gravel, ash, and clay that rest unconformably

on the Centerpoint Volcanics. This unit along with the Centerpoint Volcanics was originally included with the Bingen Sands by Veatch (1906). Its present name was given by Miser (1919, p. 23). Paleontologic evidence has established equivalency to the Austin Group of Texas and to the Coniacian of Europe (Stephenson et al., 1942).

The Tokio Sandstone is fossiliferous in many of the clay layers; however, the sands and gravels are mostly devoid of fossils, containing only a few plants and some lignite. No Bryozoa were found.

Brownstown Marl

The Brownstown Marl, regarded by Stephenson et al. (1942) as equivalent to the Santonian of Europe, consists of 140 feet of clay and sandy marl. As named by Hill (1888, p. 86), this unit included an additional 235 feet of marls and clays which were separated and named the Ozan Formation by Dane (1929, p. 46). The Brownstown Marl rests disconformably upon the Tokio Sandstone.

The whole Brownstown Marl section represents deposition under marine conditions. Beautifully preserved microfossils are abundant in the sequence. Bryozoa were observed in the

marl in a fresh exposure on the Arkansas-Oklahoma line. Although fragments of mollusks were common, few contained incrustations of Bryozoa.

Taylor Group

Ozan Formation

The Ozan Formation, equivalent to the lower Campanian of Europe (Stephenson et al., 1942), was named by Dane (1929, p. 58) for 235 feet of fossiliferous, gray, calcareous, sandy clays. Veatch (1906, p. 25) and Hill (1901, p. 340) included these clays in the Brownstown Marl. The Ozan Formation includes a basal coarse, glauconitic sand that approaches 20 feet in thickness. This sand was called the Buckrange sand lentil by Dane (1929, p. 59). Shark teeth, phosphatic nodules, and shell fragments constitute a large part of the sand. Bryozoa were collected from this sand at a locality (0-1) in Oklahoma adjacent to the Arkansas state line. This locality and its relationship to the Gober Chalk of Texas has been discussed by Paulson (1960).

Many of the beds consist almost wholly of Gryphaea convexa and Gryphaea sp., and it was from these units that

most of the Bryozoa were collected. Occasionally the valves have more than one species of Bryozoa incrusting the outer surfaces.

The Ozan Formation represents nearshore marine conditions as indicated by the occurrence of the biostromes of pelecypods.

Annona Chalk

The name Annona Chalk was adopted by Veatch (1906, p. 25) for 100 feet of chalk and marl considered by Stephenson *et al.* (1942) to be equivalent to the middle part of the Campanian of Europe.

The formation consists of massive and bedded white chalks and marls. Typically, the chalk and marl layers are rythmically bedded, the chalks being about four times as thick as the marls. The marly layers contain sparse to numerous microfossils; the chalky layers containing only sparse, poorly preserved fossils.

The Annona Chalk thins to the east; just before it disappears, near Yancy, Arkansas, it is very fossiliferous, containing a well-preserved assemblage of mollusks, but no bryozoans. In the cement quarry at Okay, Arkansas, a few

bryozoan casts were found but were in such poor condition that they could not be identified.

Marlbrook Marl

Hill (1888, p. 188) placed all the beds above the Brownstown Marl and below the Nacatoch Sandstone in the Gryphaea vesicularis chalk marls. Veatch (1906) was the first to use the name Marlbrook Marl. He included the Saratoga Chalk and part of the Nacatoch Sandstone in this unit. Dane (1929, p. 91) restricted the name, "to the marls that lie above the Annona Chalk or the Ozan Formation and below the Saratoga Chalk." The Marlbrook as thus restricted has been correlated by Stephenson et al. (1942) with the upper part of the Campanian.

The formation is approximately 175 feet thick and consists of bedded, blue-gray marl that weathers to a light gray. Many pelecypods weather out of the marl. It contains abundant, well-preserved Foraminifera and Ostracoda. No Bryozoa were found.

Saratoga Chalk

The name Saratoga Chalk was first used by Branner (1898, p. 53) for 20 feet of chalk, marl, and clay cropping out on the northern edge of Saratoga, Arkansas. In 1902, Taff (p. 714) redescribed the formation and noted that the basal unit of the Saratoga Chalk consists of a bed of Gryphaea vesicularis shells lying disconformably on the Marlbrook. The formation is very similar to the Annona (interbedded chalk and marl).

Drouant (1959) identified the argillaceous, calcareous sands at the base of the high bluff on the Ouachita River north of Arkadelphia, Arkansas, as a facies of the Saratoga Chalk, apparently equivalent to the uppermost clay at the type locality of the Saratoga. The Saratoga Chalk correlates with the lower part of the Maastrichtian of Europe (Stephenson et al., 1942).

Dane (1929, p. 110-111) listed 45 species of invertebrates identified by L. W. Stephenson. Bryozoa were mentioned in the list but not identified. The basal unit of the Saratoga Chalk, an extensive biostrome of pelecypods, has more bryozoans than any other unit in the Upper Cretaceous

in southwestern Arkansas. Gryphaea vesicularis especially served as the substrate for incrusting bryozoans.

Navarro Group

Nacatoch Sandstone

The Nacatoch Sandstone, regarded by Stephenson et al. (1942) as equivalent to the Maastrichtian of Europe, was named by Veatch (1906, p. 27) for 395 feet of fine-grained, cross-bedded sand that varies from gray to green. The green colors result from varying amounts of glauconite. The uppermost sands contain many mud casts of Halymenites major. In many localities the Nacatoch Sandstone is very fossiliferous and a lengthy list of identified fossils, mainly pelecypods, was compiled by L. W. Stephenson and listed by Dane (1929, p. 132-133). Bryozoa are listed but not identified.

High Bluff on the Ouachita River is the only locality at which the Nacatoch contains Bryozoa. In many localities, shell fragments weather free at the surface but do not contain incrusting forms.

The Nacatoch Sandstone was deposited under nearshore marine conditions, the lithology being determined largely

by proximity to stream systems. At some distance from the old stream systems, thick sequences of glauconitic sand with thick beds of clay formed. Near the stream systems massive sands with laminations of clay usually accumulated.

Arkadelphia Marl

Hill (1888, p. 53) named the Arkadelphia Marl, equivalent to the upper Maastrichtian of Europe (Stephenson et al., 1942), for 100-150 feet of dark gray, fossiliferous marl exposed around Arkadelphia, Arkansas; this unit lies disconformably on the Nacatoch Sandstone. This marl is usually covered by a deep zone of weathering; hence, good exposures are extremely rare. Only a few localities contain marl that has not been leached of fossils. In a few places larger shell fragments weather out but these have many solution pits on them. Bryozoa were lacking in all samples from the Arkadelphia.

PALEOECOLOGY OF ARKANSAS CHEILOSTOMATA

As with the European species, stratigraphic occurrence of Cheilostomata in Arkansas is variable; specimens are extremely abundant in certain beds and sparse to absent in others (Figure 3). The sporadic occurrences must be due, in large part, to environmental changes, and the major changes of faunas from Brownstown-Ozan to Saratoga-Nacatoch must be due, in some part, to the same cause. However, two species, Ramphonotus pedunculatus and Pyripora brownstownensis, range through more than one formation.

During times of minimum clastic deposition in the Gulfian, shallow-water environments approaching littoral conditions supporting biostromal pelecypod accumulation, e.g. those in the Saratoga Chalk, were preferred by the Cheilostomata. Certain formations, such as the Annona Chalk, are virtually devoid of Cheilostomata.

In Europe Voigt (1962, p. 64) recorded Cheilostomata in greater abundance in sandy, littoral facies than in deeper water carbonates. The Ripley Formation, of Tennessee, a glauconitic, sandy marl, of shallow-water origin, also

supports a rich fauna (Canu and Bassler, 1926, p. 7).

Paucity of Bryozoa in some marly units, such as the Brownstown and Marlbrook, may be related to lack of a suitable substrate, e.g. shells. Where shells are common, as in the basal part of the Ozan Formation (Buckrange Sand Member) or the upper part of the Ozan which includes biostromes of Gryphaea convexa, Bryozoa are numerous and varied.

The preference of Arkansas Gulfian cheilostomes for shelly substrates accords with their dominant growth habit, membraniporiform. There is, however, another factor involved, for abundant vinculariiform zoaria of Frurionella parvipora Canu and Bassler occur in the Saratoga. The small size of most of the incrusting zoaria suggests that the habitats occupied were marginal with respect to the ranges of tolerance of the cheilostome species; perhaps they developed and died during short growing seasons.

STRATIGRAPHIC SIGNIFICANCE OF ARKANSAS CHEILOSTOMATA

The traditional correlation (Stephenson et al., 1942) based principally on ammonites is followed in order to make comparisons of stratigraphic occurrences of Cheilostomata between Europe and the United States. In general the same cheilostome genus has species occurring in similar stratigraphic intervals in the two regions. This is demonstrated by the series of figures (5-17) showing how species of the same genus match. Similar ecologic controls seem to have been exerted on their occurrence.

The major change in Cretaceous bryozoan faunas occurs in Europe at the base of the Campanian (Voigt, 1959, p. 102-104). Cheilostomata became dominant over Cyclostomata, ascophoran Cheilostomata appeared for the first time, and anascan and cribrimorph Cheilostomata are represented by more progressive genera. Even so, there have been 21 genera of Cheilostomata described from Cenomanian, Turonian, Coniacian, and Santonian beds in Europe. In Arkansas, on the other hand, the first Upper Cretaceous occurrence of Cheilostomata is in Santonian equivalents (Brownstown Marl)

which have yielded only two primitive anascan genera, the electrinid Pyripora (which ranges from Albian to Recent; Thomas and Larwood, 1956, p. 375), and the calloporid Ramphonotus (for which the Brownstown species represents the oldest occurrence of a genus ranging to recent). Cribrimorph Cheilostomata (Suborder Acanthostega; see Cheetham, 1963, p. 60), which appeared in Europe in the Coniacian, delayed their Arkansas appearance until Campanian (Ozan Formation). In Europe 26 genera of Cheilostomata are known from the Campanian; only seven are present in equivalent deposits in Arkansas, but middle and upper Campanian beds (Annona and Marlbrook) have yielded no identifiable bryozoans. The first appearance of Ascophora accords with the European record; Stictostega and Escharoides (?) occur in the Ozan. Anasca in the Ozan include primitive genera, Pyripora, Ramphonotus, and Alderina, and a more advanced microporid, Aechmella.

The passage from Campanian to Maastrichtian in Europe is marked by an increase in diversity of cheilostome genera as well as by development of more progressive genera in all three suborders. The European section includes 35 genera (Voigt, 1959, p. 705) to 19 for the American equivalents.

The anascan Cheethamia appears to be a precise index to the Maastrichtian on both sides of the Atlantic. The ascophoran Frurionella appears on both sides of the Atlantic at the base of the Maastrichtian but in Europe ranges up into the Danian. The anascan Dionella (which ranges from Coniacian to Maastrichtian in Europe) and the cribrimorphs Tricephalopora (Coniacian to Danian in Europe) and Castanopora (Campanian to Danian in Europe) are represented for the first time in Arkansas in the Saratoga; and the first two by more than one species.

In general, the first occurrences of genera are younger in Arkansas than in Europe, if they are not synchronous. Diacanthopora is an exception, appearing in the Ozan (lower Campanian) for the first time on this side of the Atlantic, but not until the Danian in Europe. Only one Arkansas genus, Stictostega, is not found in the European Cretaceous at all.

Two European Cretaceous genera absent from the Arkansas Cretaceous are the specialized anascans Coscinopleura and Lunulites, both of which made their American appearance in the Paleocene. Ecological factors related to the substrate probably excluded both of them from Arkansas in the

Cretaceous.

The ratio between the number of genera of Anasca, Acanthostega, and Ascophora, compiled for the European Cretaceous and Paleocene stages from Voigt (1959, p. 704-705) with modifications, shows a trend similar to that for the Arkansas cheilostomes (Figure 4). Though Acanthostega and Ascophora played an increasingly important role in cheilostome faunas, Anasca remained dominant throughout the Cretaceous. Not until Eocene time did Ascophora exceed Anasca in diversity, and from Eocene onward Acanthostega were severely reduced in numbers. On the basis of similarities with the European Cheilostomota the Cretaceous faunas of Arkansas must be regarded as typically Cretaceous.

CONCLUSIONS

A taxonomic study (Systematic Descriptions, p. 28) of Cheilostomata from the Upper Cretaceous formations of southwestern Arkansas led to the following conclusions.

1. The sporadic distribution of the cheilostome Bryozoa in the Arkansas Gulfian and the major changes between the bryozoans in the Brownstown-Ozan and Saratoga-Nacatoch are at least in part related to ecological factors, probably the nature of the substrate.
2. In spite of the sporadic distribution of Cheilostomata in the Upper Cretaceous of Arkansas, the major morphological changes in this group are similar to those in the Upper Cretaceous of Europe.
3. All three suborders of Cheilostomata (Anasca, Acanthostega, and Ascophora) are represented in the Upper Cretaceous formations of southwestern Arkansas. These vary in simplicity from the primitive anascan, *Pyripora brownstownensis* to the highly specialized ascophoran species, *Escharoides ? nomas*.

4. Similar species of cheilostome Bryozoa in general have similar ranges in Arkansas and Europe, if the standard correlation of the Cretaceous is accepted.
5. Where the ranges are not synchronous, most genera have earlier appearance in Europe than in Arkansas.

Fig. 1. Cretaceous Outcrops Sampled

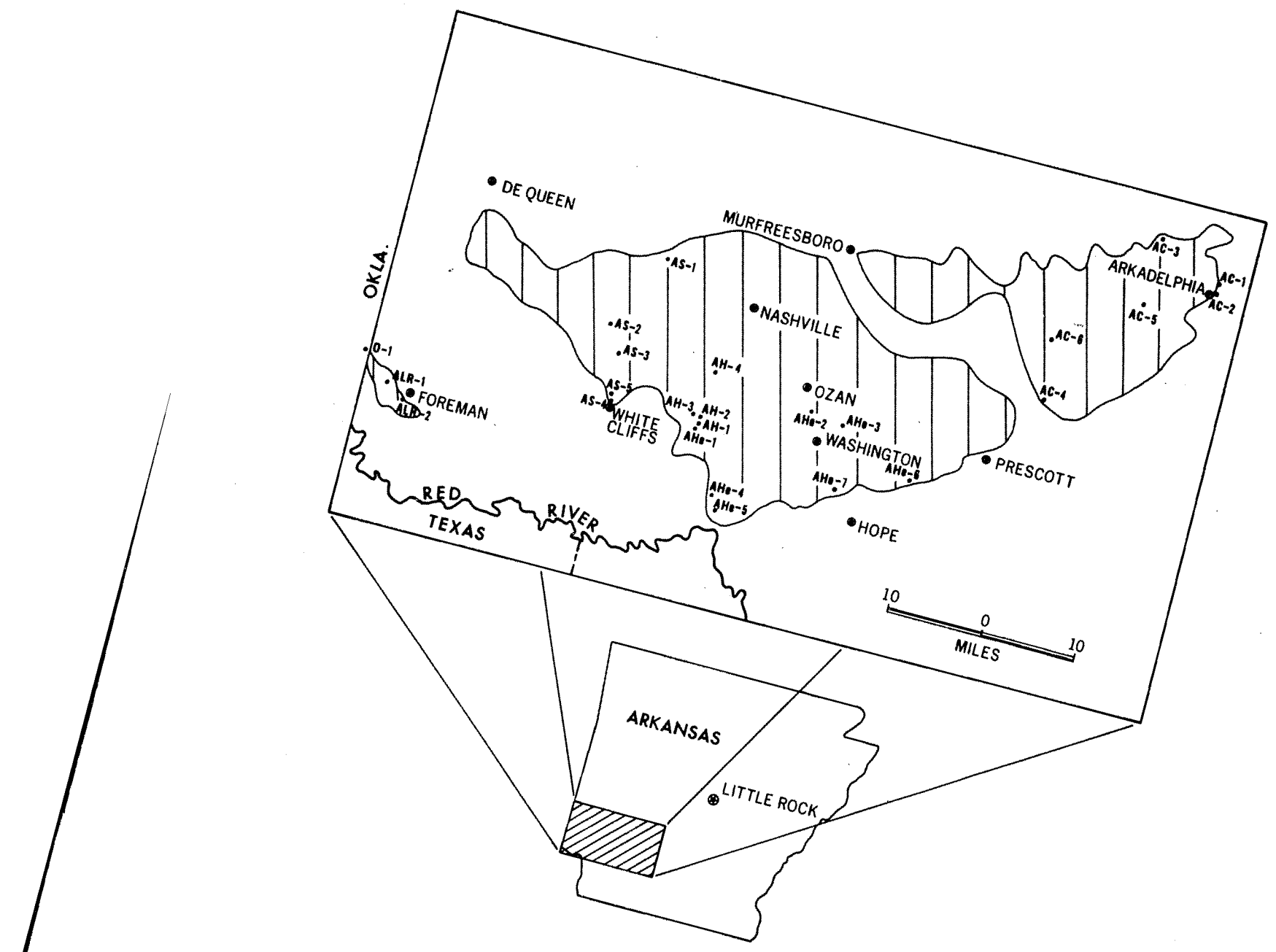

DE QUEEN
MURFREESBORO
OKLA.
NASHVILLE
ARKADELPHIA
AC-1
AC-2
AC-3
AC-4
AC-5
AC-6
AS-1
AS-2
AS-3
AS-4
AS-5
AH-1
AH-2
AH-3
AH-4
AHe-1
AHe-2
AHe-3
AHe-4
AHe-5
AHe-6
AHe-7
O-1
ALR-1
ALR-2
FOREMAN
WHITE CLIFFS
OZAN
WASHINGTON
PRESCOTT
HOPE
RED RIVER
TEXAS
10
0
10
MILES
ARKANSAS
LITTLE ROCK

Fig. 2. Generalized geologic section of exposed Gulfian Cretaceous formations in southwestern Arkansas and correlation with Europe. (Compiled from Stephenson et al., 1942; Larwood, 1962; Shreveport Geological Society Guidebook, 1961)

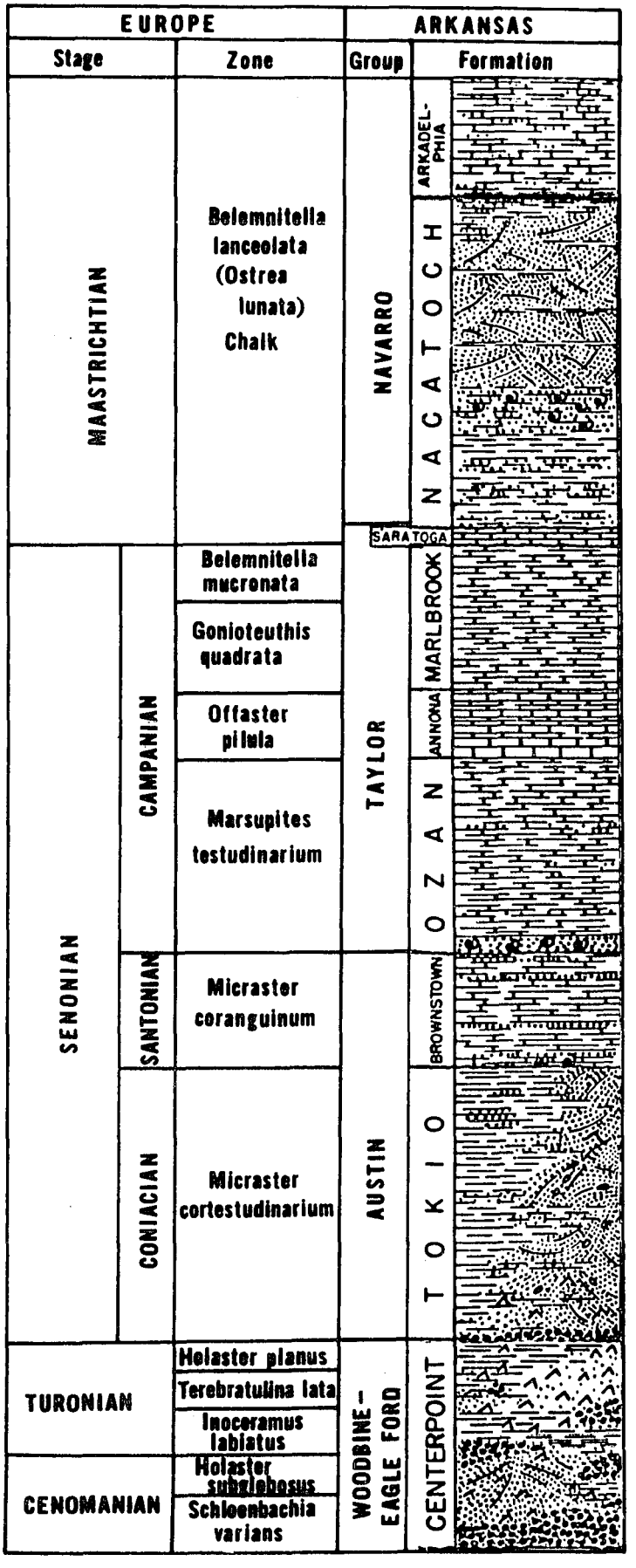

EUROPE
ARKANSAS
Stage
Zone
Group
Formation
MAASTRICHTIAN
Belemnitella lanceolata (Ostrea lunata) Chalk
NAVARRO
ARKADELPHIA
NACATOCH
SARATOGA
SENONIAN
CAMPANIAN
Belemnitella mucronata
Gonioteuthis quadrata
Offaster pilula
Marsupites testudinarium
TAYLOR
MARLBROOK
ANNONA
OZAN
SANTONIAN
Micraster coranguinum
BROWNSTOWN
CONIACIAN
Micraster cortestudinarium
AUSTIN
TOKIO
TURONIAN
Holaster planus
Terebratulina lata
Inoceramus labiatus
WOODBINE-EAGLE FORD
CENTERPOINT
CENOMANIAN
Holaster subglobosus
Schloenbachia varians
Silty marls 100'-125'
Massive, cross-bedded sands; glauconitic in part, with interbedded clays 395'
Hard, white chalk 20'
Soft, gray, chalky shales 175'
Massive white chalk 100'
Calcareous, sandy clays with glauconitic sands. Becomes chalky at top 235'
Buckrange Sand Member 20'
Calcareous & sandy clay 140'
Cross-bedded clean quartz sand with volcanic ash, gravels & gray clay 345'
Cross-bedded tuffs, tuffaceous sands, interbedded gravels, red & gray clay 250'

Fig. 3. Distribution and abundance of cheilostome Bryozoa in Gulfian rocks of Arkansas

	Brownstown Marl	Ozan Fm.	Annona Chalk	Marlbrook Marl	Saratoga Chalk	Nacatoch Sandstone
Solenophragma elongatum, n. sp.						1
Solenophragma sp.						1
Solenophragma ovatum (Canu & Bassler)					2	
Tricephalopora arkansasensis, n. sp.					2	
Tricephalopora larwoodi, n. sp.					11	
Cheethamia howei, n. sp.					6	
Frurionella parvipora Canu & Bassler					133	
Escharoides ? danei, n. sp.					10	
Ellisina saratogaensis, n. sp.					4	
Dionella vivistratensis, n. sp.					3	
Dionella racemata, n. sp.					6	
Micropora ? sp.					4	
Castanopora spooneri (Butler & Cheetham)					24	
Ramphonotus pedunculatus, n. sp.	1	12				
Stictostega durhami, n. sp.		2				
Diacanthopora langi, n. sp.		1				
Alderina inuber, n. sp.		1				
Aechmella ozanensis, n. sp.		2				
Escharoides ? sp.		1				
Escharoides ? nomas, n. sp.		1				
Escharoides ? erymnos, n. sp.		1				
Pyripora brownstownensis, n. sp.	12	2				
TOTAL	13	23	0	0	209	2

Numbers indicate identifiable zoaria and zoarial fragments collected

Fig. 4. Generic ratios of Anasca, Acanthostega, and Ascophora in Cretaceous and Paleocene rocks in Europe and North America (European genera compiled from Voigt, 1959, p. 704)

	Europe	North America
Danian	12 : 6 : 11	4 : 1 : 3
Maastrichtian	16 : 4 : 15	5 : 2 : 2
Campanian	13 : 3 : 8	4 : 1 : 2*
Santonian	11 : 6 : 0	2 : 0 : 0
Coniacian	9 : 6 : 0	———
Turonian	7 : 0 : 0	———
Cenomanian	6 : 0 : 0	———

First, second, and third numbers refer to number of genera of Anasca, Acanthostega, and Ascophora respectively.

*1 genus of Ascophora is restricted to the United States.

SYSTEMATIC DESCRIPTIONS

Order Cheilostomata Busk, 1852

Suborder Anasca Levinsen, 1909

Family Electridae Lagaaij, 1952

Genus *Pyripora* d'Orbigny, 1849

Pyripora brownstownensis, new species

Plate 1, figure 2

Etymology.--For the Brownstown Formation, in which it occurs.

Material.--Holotype 8232, Louisiana State University Geology Museum. Four other zoarial fragments, paratypes 8254 to 8257.

Diagnosis.--*Pyripora* having membraniporiform, uniserial zoarium, branching bilaterally and distally, the zooecia connected by elongate, narrow, stolon-like caudal portions; gymnocyst finely granular; cryptocyst lacking.

Description.--Zoarium membraniporiform, incrusting various shell fragments, mainly *Exogyra ponderosa*. Zooecia arranged in uniserial, branching rows, connected by their elongate, slender caudal portions, branching distally and bilaterally.

Zooecia pyriform, about twice as long as wide, with unilaminar or bilaminar (resulting from regeneration) walls; distal chamber occasionally present, resulting from regeneration; gymnocyst strongly convex, finely granular, narrowing proximally to a slim, stolon-like caudal portion which extends one fourth to almost one-half zooecial length from proximal margin; mural rim smooth, rounded, narrow, of uniform thickness on proximal and distal margins; cryptocyst lacking.

Aperture elongate, elliptical, twice as long as wide, with proximal and distal margins rounded, lateral margins broadly rounded; filled in some zooecia with porous wall of closure separated from mural rim by a well-marked groove and a small, half-moon shaped to circular scar of an opesia terminal on the slightly inflated distal margin.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	9	0.71 mm	0.036 mm	0.66 - 0.77 mm
lz	9	0.34 mm	0.018 mm	0.31 - 0.36 mm
ha	9	0.47 mm	0.023 mm	0.44 - 0.51 mm
la	9	0.18 mm	0.014 mm	0.17 - 0.22 mm

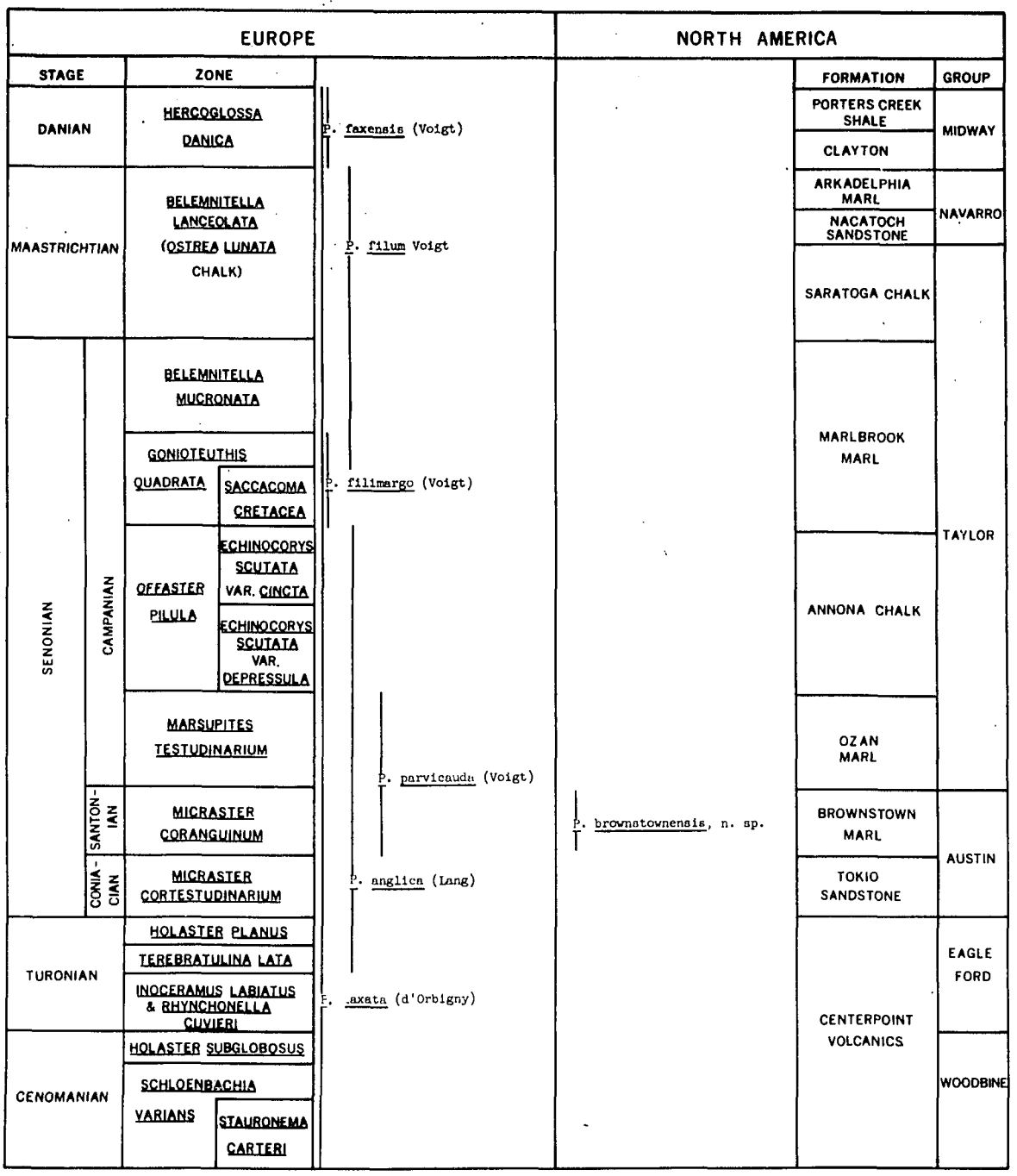
Occurrence.--Shell bed consisting of Exogyra ponderosa debris, in upper two feet of Brownstown Formation. Locality 0-1.

Discussion.--P. brownstownensis is similar to P. anglica (Lang) but differs in lacking a cryptocyst and in having less variable dimensions.

P. brownstownensis is also similar to P. texana Thomas and Larwood, described from the Albian of Texas and compared to P. cruciata (Reuss) from the Upper Cretaceous of Nefgraben, Gosau, Austria. According to the measurements given by Thomas and Larwood (1956, p. 375), P. texana has smaller apertures and opesiae and shorter and wider caudae than P. brownstownensis, but the slight difference in dimensions is probably not as significant as the lack of cryptocyst in P. brownstownensis.

The range of P. brownstownensis (Figure 5) occurs within the range of P. anglica, with which it compares most closely morphologically.

Fig. 5. Range chart of species of Pyripora


EUROPE
NORTH AMERICA
STAGE
ZONE
FORMATION
GROUP
DANIAN
HERCOGLOSSA DANICA
P. faxensis (Voigt)
PORTERS CREEK SHALE
CLAYTON
MIDWAY
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
P. filum Voigt
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
P. filimargo (Voigt)
MARLBROOK MARL
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
ANNONA CHALK
TAYLOR
MARSUPITES TESTUDINARIUM
P. parvicauda (Voigt)
OZAN MARL
SANTONIAN
MICRASTER CORANGUINUM
P. brownstownensis, n. sp.
BROWNSTOWN MARL
CONIACIAN
MICRASTER CORTESTUDINARIUM
P. anglica (Lang)
TOKIO SANDSTONE
AUSTIN
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
P. laxata (d'Orbigny)
CENTERPOINT VOLCANICS
EAGLE FORD
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
WOODBINE

Family Hincksinidae Canu and Bassler, 1927

Genus Ellisina Norman, 1903

Ellisina Norman, 1903, p. 596, v. 11, pl. 13.

Cranosina Canu and Bassler, 1933, p. 16.

Ellisinidra Canu and Bassler, 1933, p. 18 (objective).

Type species.--Membranipora levata Hincks, 1882, p. 249 (by original designation). Recent, Queen Charlotte Islands.

Discussion.--Ellisina is used here in conformity with the usage of Hastings and Osburn. Hastings (1945, p. 87) described Ellisina as having "ovicells endozooecial and closed by the zooecial operculum. avicularium vicarious and pointed, pore chambers present." She further commented that, "It appears that the ovicell may be immersed in a kenozooecium (E. levata), a vicarious avicularium (E. antarctica) or an autozooecium (E. incrustans)." Osburn (1953, p. 49), in discussing the nomenclatural history of the genus, remarked that "Norman erected the generic name, giving levata Hincks from the Queen Charlotte Islands as the genotype, but unfortunately drew his description from a Gulf of St. Lawrence specimen which was misidentified and which belongs elsewhere. Norman's description of the genus is therefore

in error, but his selection of levata as the type definitely attaches the name Ellisina to the species levata."

Canu and Bassler (1933, p. 17) and Bassler (1953, p. G160) indicated differentiation of Ellisina and Cranosina on the basis of the ovicell, i.e., hyperstomial in the former and endozooecial in the latter. Voigt (1962, p. 32) followed them in making this distinction by referring Cretaceous species with hyperstomial ovicells to Ellisina and those with endozooecial ovicells to Cranosina. As the type species of Ellisina possesses endozooecial ovicells, those Cretaceous species referred by Voigt and others to Cranosina, some of which compare closely with E. saratogaensis, n. sp., must be transferred to Ellisina as discussed below.

Ellisina saratogaensis, new species

Plate 3, figure 1

Etymology.--After Saratoga, Arkansas, in the vicinity of which the type specimens occur.

Material.--Holotype 8233, Louisiana State University Geology Museum, a zoarial fragment with 206 zooecia visible, other zooecia masked by chalk. Two zoarial fragments, paratypes

8258 and 8259.

Diagnosis.--Ellisina having membraniporiform zoarium, hexagonal zooecia with broad cryptocyst, and a small, transverse interzooecial avicularium distal to each zooecium except those with ovicells.

Description.--Zoarium membraniporiform, incrusting valves of Gryphaea vesicularis; zooecia alternating with interzooecial avicularia in irregular, bifurcating rows radiating from ancestrula. Zooecial communication by small pore chambers irregularly placed on distal and distolateral margins.

Zooecia distinct, separated by mural rims laterally and by a short proximal gymnocyst and the interzooecial avicularia; about one and a half times as long as wide, irregularly hexagonal; distal margin rounded; proximal margin wraps around avicularium; lateral margins broadly rounded to angular. Gymnocyst poorly developed, present only on proximal margin, slightly convex, finely granular; mural rim thin, rounded, finely granular, slightly crenulate.

Cryptocyst well ceveloped, extending one-fourth of zooecial length from proximal margin, imperforate, finely granular, slightly concave, sloping steeply distally to

crenulate opesial margin; opesia large, almost trifoliate, to irregularly oval, coinciding with mural rim distally.

Avicularia interzooecial, small, circular to triangular, equilateral, varying in size, with obliquely placed opening lacking pivotal structure. Rostrum sometimes produced obliquely distally. One avicularium at distal end of each zooecium except those with ovicells.

Ovicell endozooecial, salient, bulbous, covered by the finely granular proximal gymnocyst of the distal zooecium. Proximal margin following outline of mural rim.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	10	0.52 mm	0.042 mm	0.44 - 0.55 mm
lz	10	0.53 mm	0.054 mm	0.45 - 0.64 mm
ho	10	0.37 mm	0.030 mm	0.33 - 0.44 mm
lo	10	0.32 mm	0.004 mm	0.31 - 0.35 mm
Lov	10	0.21 mm	0.028 mm	0.15 - 0.26 mm
lov	10	0.27 mm	0.005 mm	0.24 - 0.30 mm
Lav	10	0.17 mm	0.04 mm	0.13 - 0.23 mm
lav	10	0.20 mm	0.05 mm	0.13 - 0.27 mm

Occurrence.--Lowest unit of the Saratoga Chalk immediately overlying the Marlbrook Marl, in a biostrome of *Gryphaea vesicularis*. Locality AH-1.

Discussion .--Species referred by Voigt to Cranosina which should be transferred to Ellisina include Membranipora britannica Brydone (1910, p. 76), Reptoflustrella simplex and R. ovalis d'Orbigny (1851, p. 571, 572), and Cranosina subpraecursor Voigt (1962, p. 33). Of these, E. britannica is the closest to E. saratogaensis but differs in having narrower zooecia with thicker mural rim and different shaped avicularia.

The range of E. britannica (Figure 6) includes that of E. saratogaensis.

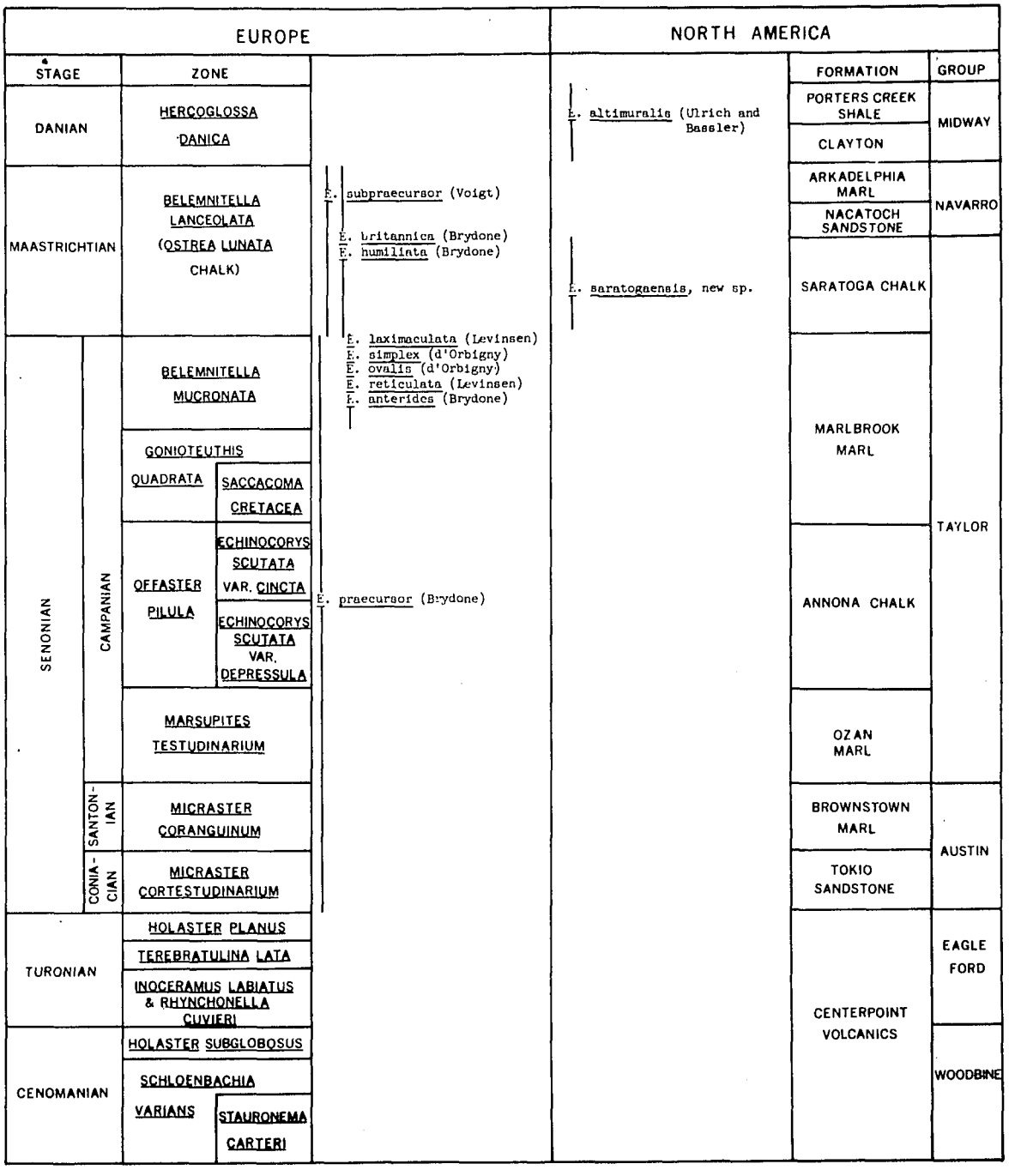
Family Calloporidae Norman, 1903

Genus Alderina Norman, 1903

Type species.--Membranipora imbellis Hincks, 1860, p. 275, pl. 30, fig. 1 (by original designation). Recent, Shetland Islands.

Discussion.--Norman (1903, p. 596) described the genus Alderina as lacking avicularia and spines but having dietellae arranged as two pairs of chambers laterally and two distinctly marked and separated chambers distally. Some species of Alderina, such as A. brevispina (O'Donoghue), have small spines (Osburn, 1953, p. 60).

Fig. 6. Range chart of species of Ellisina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NORTH AMERICA
STAGE
ZONE
FORMATION
GROUP
DANIAN
HERCOGLOSSA DANICA
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
BELEMNITELLA MUCRONATA
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
MARSUPITES TESTUDINARIUM
MICRASTER CORANGUINUM
MICRASTER CORTESTUDINARIUM
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
SENONIAN
CAMPANIAN
SANTONIAN
CONIACIAN
TURONIAN
CENOMANIAN
E. subpraecursor (Voigt)
E. britannica (Brydone)
E. humiliata (Brydone)
E. laximaculata (Levinsen)
E. simplex (d'Orbigny)
E. ovalis (d'Orbigny)
E. reticulata (Levinsen)
E. anteridos (Brydone)
E. praecursor (Brydone)
E. altimuralis (Ulrich and Bassler)
E. saratogaensis, new sp.
PORTERS CREEK SHALE
CLAYTON
MIDWAY
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
MARLBROOK MARL
ANNONA CHALK
OZAN MARL
TAYLOR
BROWNSTOWN MARL
TOKIO SANDSTONE
AUSTIN
CENTERPOINT VOLCANICS
EAGLE FORD
WOODBINE

Some confusion exists in the separation of Alderina and Aplousina Canu and Bassler. Alderina is similar to Aplousina in general zooecial morphology, but differs in one important characteristic, the presence of dietellae.

The ovicell of Alderina does not extend under the frontal wall of the distal zooecium, so it must be considered hyperstomial. Similar, but reduced ovicells in Aplousina and in Crassimarginatella Canu, have been interpreted as endozooecial (Voigt, 1962, p. 32; Berthelsen, 1962, p. 21).

Hastings (1964, p. 250-251), in commenting on the variation of ovicells in various genera, noted that in Crassimarginatella spatulifera Harmer, on one zoarium some of the ovicells are prominent and hyperstomial and some are reduced or even vestigial, occurring as just "slight modifications of the distal margin." This amount of variation within a species makes it difficult to use ovicell type as a diagnostic character in any of these genera. Therefore, Alderina may be separated from Aplousina and Crassimarginatella additionally by its lack of avicularia.

Dionella Medd resembles Alderina in general morphology and in having dietellae, but differs in possessing avicularia.

Alderina inuber, new species

Plate 1, figure 1

Etymology.--L. in-, not, and uber, full, copious, referring to the reduced ovicell.

Material.--Holotype 8234, Louisiana State University Geology Museum. A zoarial fragment with 36 zooecia.

Diagnosis.--Alderina having membraniporiform zoarium, small, regularly hexagonal zooecia, with narrow cryptocyst and reduced ovicells. Spines lacking.

Description.--Zoarium membraniporiform, incrusting valves and fragments of Gryphaea convexa, composed of zooecia in bifurcating rows radiating from ancestrula, those in adjacent rows alternating in position; zooecial communication by horizontal, slit-shaped septula on exterior of distal and distolateral walls opening into three pairs of distolateral dietellae.

Zooecia distinct, hexagonal, elongate, separated by furrows; distal margin sharply rounded; proximal margin broadly rounded; zooecial width about two-thirds length. Gymnocyst narrow, finely granular, extending length of

zooecium. Mural rim salient, finely and transversely crenulated; aperture large, oval, sharply rounded distally, broadly rounded proximally. Cryptocyst very narrow, forming a shelf on proximal and lateral margins of aperture. Opesia approximately the size and shape of aperture.

Ovicell hyperstomial, greatly reduced, having the form of a slight distal swelling, not projecting onto distal zooecium. Surface imperforate, finely granular; interior confluent with zooecial interior.

Measurements:--

	No.	Mean	Std. Dev.	Observed Range
Lz	8	0.77 mm	0.053 mm	0.66 - 0.83 mm
lz	8	0.48 mm	0.046 mm	0.44 - 0.55 mm
ho	8	0.53 mm	0.026 mm	0.48 - 0.56 mm
lo	8	0.35 mm	0.017 mm	0.33 - 0.38 mm

Occurrence.--Fifteen feet below the Ozan-Annona contact, in blue-gray, fossiliferous, sandy marl of the Ozan Formation at White Cliffs Station. Locality AS-5.

Discussion.--A. inuber differs from A. nelsoni Canu and Bassler (Ripley Formation, Coon Creek, Tennessee) in having larger zooecia and opesiae. The zooecia of A. nelsoni are rectangular rather than hexagonal and have a broad,

well-developed cryptocyst.

Although A. simplicissima (Voigt) is a European species, it resembles A. inuber more than A. nelsoni does but has a wider cryptocyst and a larger ovicell. Both species are larger than A. contumax (Canu and Bassler) from the Vincentown of New Jersey.

Primitive characteristics displayed by A. inuber include lack of spines, narrow cryptocyst, and small dimensions. The species occurs at a lower stratigraphic level than any of the European species (Figure 7), and there is a long gap between it and the nearest species in the American section.

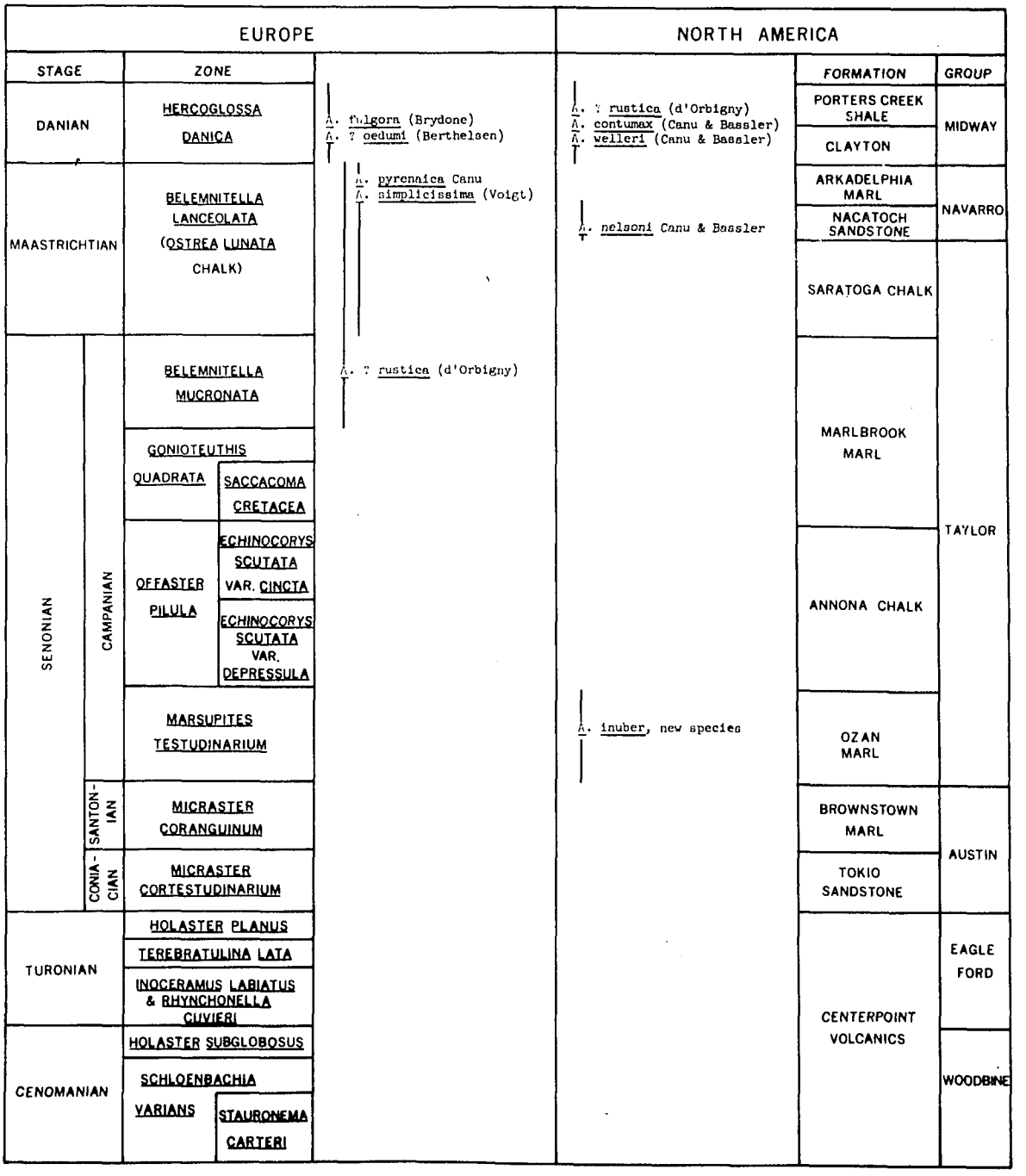
Genus Ramphonotus Norman, 1894

Ramphonotus Norman, 1894, p. 122; Lagaaij, 1952, p. 27 (with synonymy).

Type species.--Membranipora minax Busk, 1860, p. 125, pl. 25, fig. 1, 1a-b (by original designation). Recent, Shetland Islands.

Discussion.--Ramphonotus comprises a small group of calloporid species having incrusting zoaria, zooecia with narrow cryptocysts, pedunculate adventitious avicularia, and

Fig. 7. Range chart of species of Alderina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DANIAN
HERCOGLOSSA DANICA
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
MARSUPITES TESTUDINARIUM
SANTONIAN
MICRASTER CORANGUINUM
CONIACIAN
MICRASTER CORTESTUDINARIUM
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
A. fulgora (Brydone)
A. ? oedumi (Berthelsen)
A. pyrenaica Canu
A. simplicissima (Voigt)
A. ? rustica (d'Orbigny)
A. ? rustica (d'Orbigny)
A. contumax (Canu & Bassler)
A. welleri (Canu & Bassler)
A. nelsoni Canu & Bassler
A. inuber, new species
PORTERS CREEK SHALE
CLAYTON
MIDWAY
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
MARLBROOK MARL
ANNONA CHALK
OZAN MARL
TAYLOR
BROWNSTOWN MARL
TOKIO SANDSTONE
AUSTIN
CENTERPOINT VOLCANICS
EAGLE FORD
WOODBINE

hyperstomial ovicells. Dietellae occur in two lateral pairs and one distal pair. This genus resembles Amphiblestrum Gray except in having non-trifoliate opesiae and pedunculate avicularia. Canu and Bassler (1926, p. 163) suggested that the pedunculate avicularia are the only diagnostic characteristic of the genus, but the difference in opesial shape seems equally important.

The foregoing comparison of Ramphonotus with Amphiblestrum is based on the commonly accepted definition of the latter genus which, according to Brown (1952, p. 85), is open to revision because of Gray's misidentification of the type species (by monotypy), Flustra membranacea Muller, regarded as a synonym of Electra crustulenta (Pallas).

Ramphonotus pedunculatus, new species

Plate 1, figure 4

Etymology.--L., pedunculus, little foot, and -atus, provided with, referring to the avicularia.

Material.--Holotype 8235, Louisiana State University Geology Museum, a zoarial fragment consisting of 35 zooecia, incrusting Exogyra ponderosa. Four other specimens, paratypes 8260-8263.

Diagnosis.--Ramphonotus having oval opesiae, as many as five pedunculate adventitious avicularia per zooecium, and spatulate vicarious avicularia. Cryptocyst narrow, gymnocyst well developed.

Description.--Zoarium membraniporiform, incrusting valves and debris of Exogyra ponderosa; zooecia arranged in rows radiating from ancestrula, those in adjacent rows alternating in position. Zooecial communication by large dietellae, generally united along distal and disto-lateral margins.

Zooecia irregularly hexagonal, one and a half times as long as wide, bounded by furrows which become obscured by extreme development of adventitious avicularia, distal margin rounded; proximal margin narrow and truncate to rounded; lateral margins broadly rounded. Gymnocyst extends one-third of zooecial length from proximal margin; surface finely granular, gently convex. Mural rim raised, sharp, with transverse crenulations; both distal and proximal margins rounded; lateral margins straight, finely granular. Cryptocyst imperforate, finely granular, with transverse crenulations on proximal and lateral margins; narrow, steeply sloping, becoming narrower distally.

Opesia oval with rounded distal and proximal margins;

opesiular indentations not differentiated.

Avicularia vicarious and adventitious. Vicarious avicularia rare, with well-developed distal shelf and spatulate rostrum directed distally. Adventitious avicularia pedunculate, rounded, without pivotal bar; a large one occurs on proximal gymnocyst; a maximum of four, two distal and two proximal, occurs on mural rim.

Ovicell hyperstomial, bulbous, about as wide as long; surface imperforate, finely granular; distal margin semicircular, tending to be hidden by distal avicularium as calcification progresses.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	8	0.50 mm	0.02 mm	0.48 - 0.54 mm
lz	8	0.34 mm	0.022 mm	0.32 - 0.38 mm
ho	8	0.28 mm	0.005 mm	0.26 - 0.31 mm
lo	8	0.20 mm	0.01 mm	0.17 - 0.21 mm
Lov	8	0.15 mm	0.004 mm	0.14 - 0.17 mm
lov	8	0.15 mm	0.03 mm	0.14 - 0.22 mm
Lav	8	0.11 mm	0.006 mm	0.09 - 0.13 mm)
lav	8	0.09 mm	0.004 mm	0.08 - 0.12 mm) adventitious)
Lav	7	0.21 mm	0.022 mm	0.18 - 0.25 mm)
lav	7	0.15 mm	0.033 mm	0.12 - 0.21 mm) vicarious)

Occurrence.--Uppermost unit of the Ozan Formation in a glauconitic, calcareous sandstone, incrusting Exogyra ponderosa, White Cliffs Station, Arkansas. Locality AS-5. Uppermost unit of Brownstone Marl in a glauconitic, shelly marl. Locality 0-1. Lowermost unit of Saratoga Chalk in a fossiliferous chalk. Locality AH-1.

Discussion.--R. pedunculatus differs from R. regularis Canu and Bassler (1920, p. 165), from the Castle Hayne Limestone (Eocene) of North Carolina, in having larger zooecia, as many as five pedunculate avicularia rather than two, and an oval opesia.

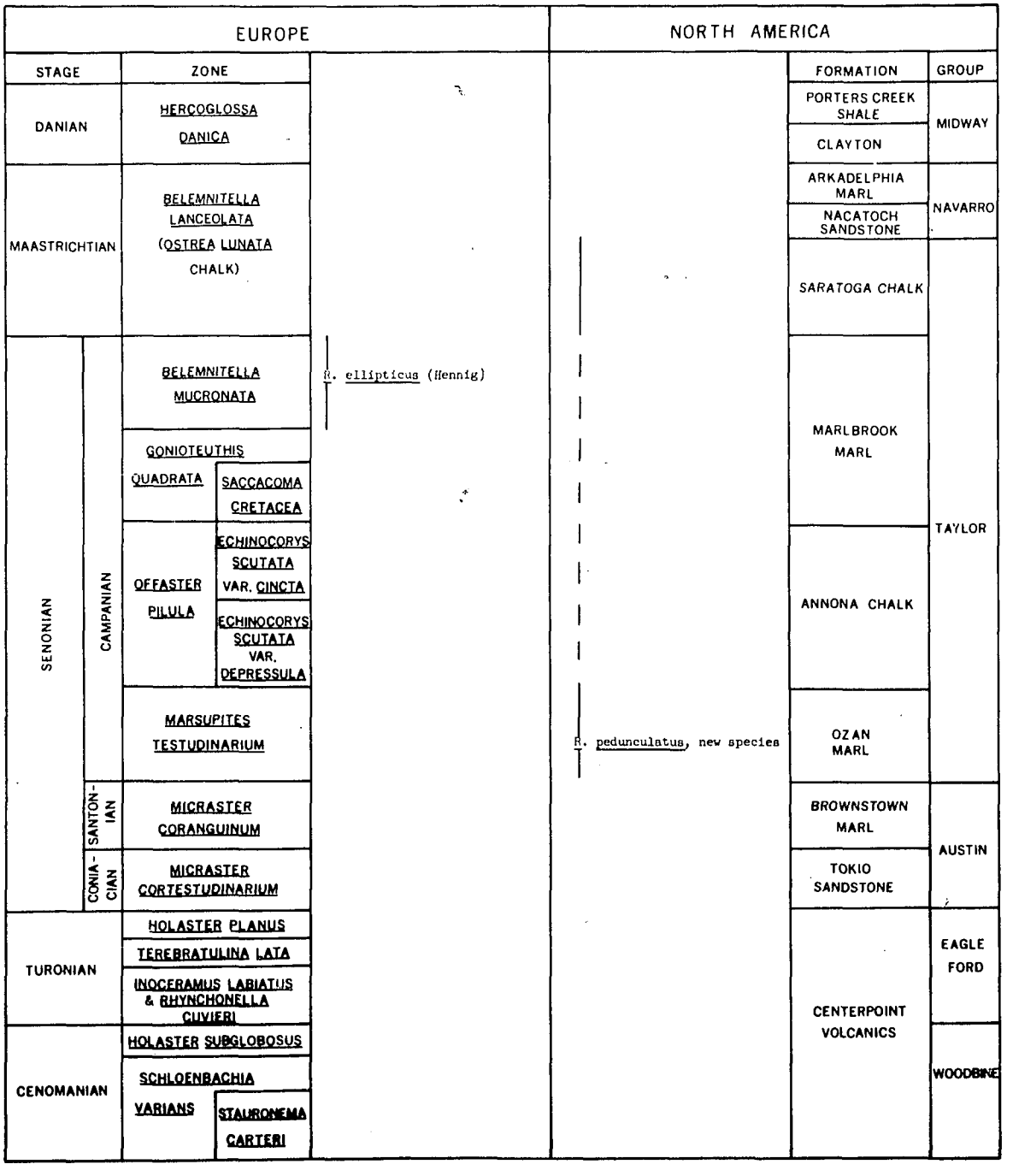
R. pedunculatus ranges lower stratigraphically than any species of Ramphonotus previously described (Figure 8). The species whose range zone in Europe approximates that of R. pedunculatus is R. ellipticus (Hennig) from the Belemnitella mucronata zone of Sweden.

Genus Solenophragma Marsson, 1887

Solenophragma Marsson, 1887, p. 54; Voigt, 1962, p. 34 (with synonymy).

Type species.--Flustrina baculina d'Orbigny, 1851, p. 301,

Fig. 8. Range chart of species of Ramphonotus


EUROPE
NORTH AMERICA
STAGE
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GROUP
DANIAN
HERCOGLOSSA DANICA
PORTERS CREEK SHALE
CLAYTON
MIDWAY
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
R. ellipticus (Hennig)
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
MARLBROOK MARL
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
ANNONA CHALK
TAYLOR
MARSUPITES TESTUDINARIUM
R. pedunculatus, new species
OZAN MARL
SANTONIAN
MICRASTER CORANGUINUM
BROWNSTOWN MARL
AUSTIN
CONIACIAN
MICRASTER CORTESTUDINARIUM
TOKIO SANDSTONE
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
CENTERPOINT VOLCANICS
EAGLE FORD
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
WOODBINE

pl. 701, figs. 13-16 (by monotypy). Cretaceous (Campanian), France.

Discussion.--Solenophragma is similar to some species of Crassimarginatella Canu, especially to C. leucocypha Marcus, which Cheetham and Sandberg (1964, p. 1017) described as having "small, triangular chamberlets, some forming kenozooecia, others transformed into avicularia, others calcified over to form tubercles, scattered among zooecia." Cheetham and Sandberg (1964, p. 1017) went on to say that, "This species is easily confused with species of Conopeum Gray, and in much of the American literature it has been identified with C. reticulum (Linne). Its generic assignment is still questionable." Osburn (1950, p. 51) placed C. leucocypha in Antropora Norman in which the ovicell is endozooecial, whereas that of Crassimarginatella is hyperstomial or vestigial. Canu and Bassler (1926, p. 32-33) described four species, including S. ovatum discussed below, from the Ripley Formation at Coon Creek, Tennessee, as members of the genus Conopeum. These species from the Ripley Formation are all referable to Solenophragma.

Conopeum ? ramosum Toots and Cutler (1962, p. 84), from the "Mesaverde Formation" of southeast Wyoming, also

belongs to Solenophragma. This species has "interzooecial spaces . . . of three different kinds . . . characterized by having separate walls. This strongly indicates that they are heterozooecia. Most common are small, triangular ones, which regularly occur at the junction of three adjacent zooecia" (Toots and Cutler, 1962, p. 84).

In summary, Solenophragma differs from Crassimarginatella in lacking ovicells and from Conopeum in having the interzooecial spaces separated from the zooecia by their own walls and usually having some of them occupied by avicularia or other heterozooecia.

Solenophragma elongatum, new species

Plate 2, figure 2

Etymology.--L., elongatus, elongate, for the shape of the zoarium.

Material.--Holotype 8236, Louisiana State University Geology Museum, a zoarial fragment containing 66 zooecia.

Diagnosis.--Erect Solenophragma with zooecia arranged in eleven regular rows. Cryptocyst well developed. Interzooecial spaces reduced to triangular openings.

Description.--Zoarium erect, cylindrical, hollow, the zooecia usually in eleven rows but sometimes with more added by bifurcation. Zooecia in adjacent rows alternate in position. Interzooecial communication by a single simple or multiporous septulum between zooecia of the same row.

Zooecia distinct, elongate, hexagonal, almost twice as long as wide, separated by small furrow between mural rims; rounded distally, slightly concave proximally. Gymnocyst lacking. Mural rim salient, concentrically wrinkled, finely granular, tending to flare in some zooecia, enclosing an ovoid aperture.

Cryptocyst narrow, concave, flattening distally, merging distally with lateral margins of mural rim; surface finely perforate, smooth, opesiular indentations not evident.

Opesia broadly rounded to truncate proximally; sharply rounded distally.

Interzooecial spaces small, tear-drop shaped, with thin walls separating them from zooecia. Lacking between some zooecia.

Measurements.--

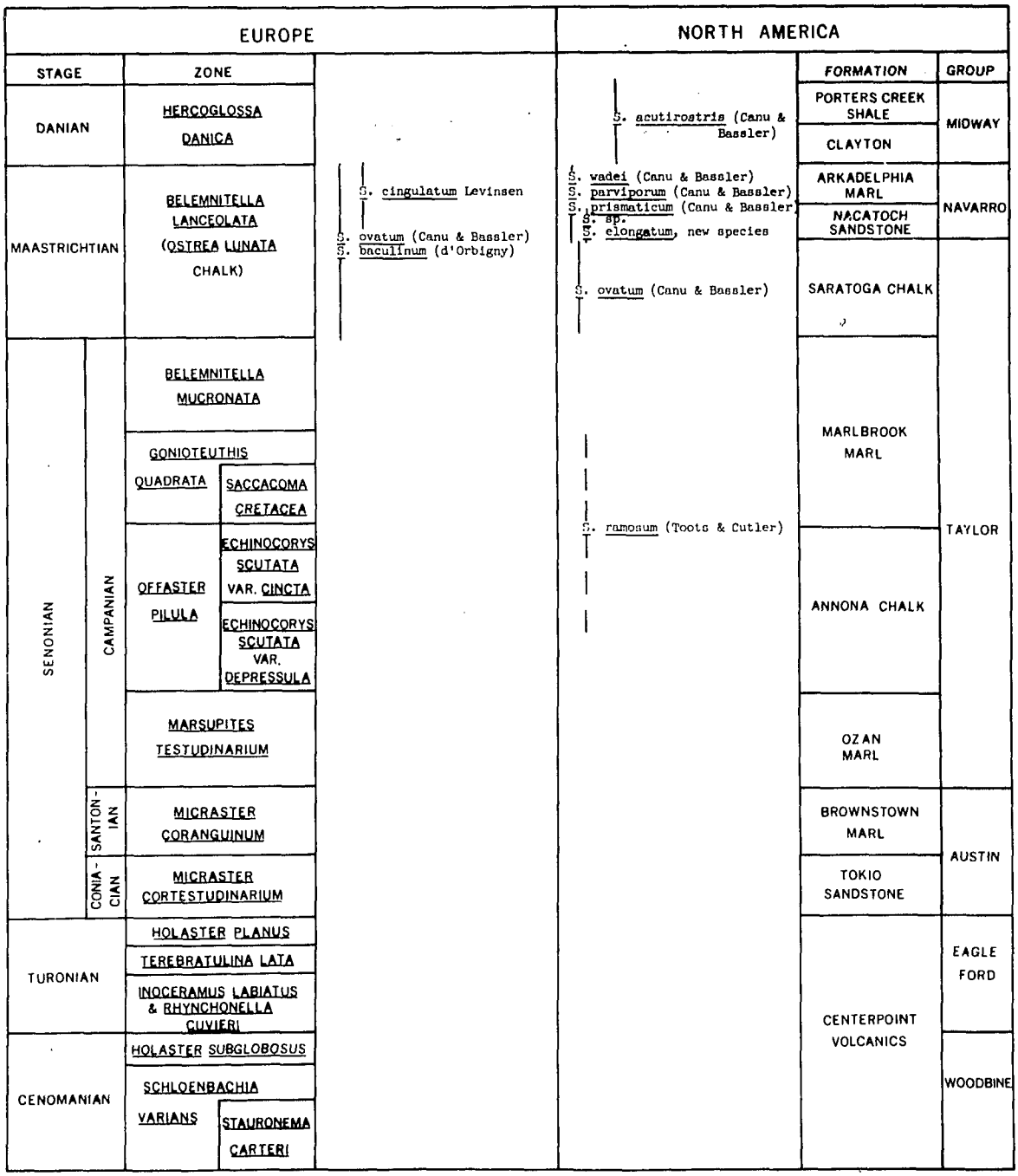
	No.	Mean	Std. Dev.	Observed Range
Lz	10	0.31 mm	0.010 mm	0.29 - 0.33 mm
lz	10	0.19 mm	0.038 mm	0.17 - 0.22 mm
ha	10	0.19 mm	0.004 mm	0.17 - 0.22 mm
la	10	0.14 mm	0.032 mm	0.12 - 0.15 mm

Occurrence.--Calcareous ledge at the base of the Nacatoch Sandstone, Taylor Group, at High Bluff, on the Ouachita River. Locality AC-1.

Discussion.--S. elongatum differs from S. cylindricum (Canu and Bassler) and S. ovatum (Canu and Bassler) in the hexagonal shape of its zooecia, in the reduction of its interzooecial spaces which never seem to form avicularia, in the greater development of its cryptocyst, and in the smaller size of its zooecia and opesiae.

S. elongatum occurs at the same stratigraphic level as numerous species in Europe and in North America (Figure 9). Most of the species of Solenophragma are of Maastrichtian age.

Fig. 9. Range chart of species of Solenophragma


EUROPE
NORTH AMERICA
STAGE
ZONE
FORMATION
GROUP
DANIAN
HERCOGLOSSA DANICA
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
MARSUPITES TESTUDINARIUM
SANTONIAN
MICRASTER CORANGUINUM
CONIACIAN
MICRASTER CORTESTUDINARIUM
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
S. cingulatum Levinsen
S. ovatum (Canu & Bassler)
S. bacillinum (d'Orbigny)
S. acutirostris (Canu & Bassler)
S. wadei (Canu & Bassler)
S. parviporum (Canu & Bassler)
S. prismaticum (Canu & Bassler)
S. sp.
S. elongatum, new species
S. ovatum (Canu & Bassler)
S. ramosum (Toots & Cutler)
PORTERS CREEK SHALE
CLAYTON
MIDWAY
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
MARLBROOK MARL
ANNONA CHALK
OZAN MARL
TAYLOR
BROWNSTOWN MARL
TOKIO SANDSTONE
AUSTIN
CENTERPOINT VOLCANICS
EAGLE FORD
WOODBINE

Solenophragma ovatum (Canu and Bassler), 1926

Plate 2, figure 3

Conopeum ovatum Canu and Bassler, 1926, p. 32, pl. 4, figs. 1-4.

Solenophragma ovatum (Canu and Bassler); Voigt, 1964, p. 34, pl. 18, figs. 1-3.

Material.--Figured specimen 8250, Louisiana State University Geology Museum, a zoarial fragment containing 36 zooecia.

Diagnosis.--Erect Solenophragma having ovoid zooecia without gymnocyst and large avicularia occupying most of the interzooecial spaces.

Description.--Zoarium erect, cylindrical, hollow, with zooecia in ten longitudinal rows, those in adjacent rows alternating in position. Interzooecial communication by a single large septulum connecting zooecia of the same row.

Zooecia distinct, elongate oval, twice as long as wide; separated by a shallow furrow. Gymnocyst lacking; aperture large and oval, outlined by a thin, finely granular mural rim. Cryptocyst concave, narrow, smooth, imperforate; present only at proximal end of aperture.

Opesia large, elongate oval, without opesiular indentations.

Avicularia large, occupying interzooecial spaces, with beaks extending around distolateral margin to midline of zooecium; rostrum elongate, sharp, slightly arcuate and asymmetrical; opening triangular or drop-shaped, with pivotal bar.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	10	0.45 mm	0.016 mm	0.42 - 0.48 mm
lz	10	0.21 mm	0.019 mm	0.18 - 0.25 mm
ha	10	0.38 mm	0.20 mm	0.34 - 0.42 mm
la	10	0.16 mm	0.016 mm	0.11 - 0.18 mm
Lav	10	0.32 mm	0.046 mm	0.25 - 0.42 mm
lav	10	0.07 mm	0.016 mm	0.05 - 0.11 mm

Occurrence.--Five feet below the Nacatoch Sandstone in a marl of the Saratoga Chalk. Locality AH-1.

Discussion.--Canu and Bassler (1926, p. 32) described four species of Conopeum from the Ripley Formation at Coon Creek, Tennessee. The small differences considered by them to be specific may be only intrapopulation variation; however, no decision can be made until adequate material from that

locality can be studied.

Voigt's (1964, p. 34) assignment of C. ovatum to Solenophragma is followed here. S. ovatum has an extraordinarily wide geographic distribution, from Arkansas to Tennessee to the Crimea (Voigt, 1964, p. 34); yet its stratigraphic range is restricted to the Maastrichtian and upper Campanian.

Solenophragma sp.

Plate 1, figure 3

Material.--Figured specimen 8238, Louisiana State University Geology Museum, a zoarial fragment with four complete zooecia.

Diagnosis.--Erect Solenophragma having elongate oval zooecia with gymnocyst and small avicularia occupying the interzooecial spaces.

Description.--Zoarium erect, cylindrical, hollow, with zooecia arranged in six rows, those in adjacent rows alternating in position.

Zooecia distinct, elongate oval, about half as wide as long, separated by a shallow furrow; distal margin rounded;

proximal margin rounded or truncate. Gymnocyst slightly convex to flat, finely granular, extending about one-third zooecial length from proximal margin; aperture oval, surrounded by salient, rounded, finely granular mural rim which thickens distally and merges with cryptocyst proximally. Cryptocyst well developed, smooth, imperforate, wide proximally, merging with lateral walls distally, moderately concave.

Opesia elongate oval, without differentiated opesiular indentations.

Avicularia small, elliptical, occupying interzooecial spaces, oriented longitudinally, with rostrum directed distally, arranged regularly at every zooecial corner; rostrum pointed; opening elliptical, divided by pivotal bar. (One large zooecium about twice as large as normal zooecia and of smae general form; gymnocyst somewhat shorter in proportion; cryptocyst lacking and with small circular distal chamber within mural rim separated from zooecial interior by curved wall (result of secondary calcification).

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	4	0.513 mm	0.012 mm	0.51 - 0.54 mm
lz	4	0.222 mm	0.01 mm	0.25 - 0.29 mm
ha	4	0.273 mm	0.014 mm	0.25 - 0.29 mm
la	4	0.148 mm	0.022 mm	0.12 - 0.17 mm
ho	4	0.125 mm	0.074 mm	0.12 - 0.13 mm
lo	4	0.075 mm	0.074 mm	0.06 - 0.08 mm
Lav	4	0.085 mm	0.010 mm	0.07 - 0.10 mm
lav	4	0.034 mm	0.000 mm	0.034 mm

Occurrence.--Calcareous ledge at base of Nacatoch Sandstone. Locality AC-1.

Discussion.--As only the single fragment of this species is known, it is being left nomen apertum despite its considerable difference from other species of Solenophragma.

Genus Dionella Medd, 1965

Dionella vivistratensis, new species

Plate 2, figure 1

Etymology.--L., vita, life, stratum, bed, and -ensis, referring to its occurrence in a biostrome.

Material.--Holotype 8239, Louisiana State University Geology Museum, a zoarial fragment with 128 complete zooecia;

paratypes 8264 and 8265.

Diagnosis.--*Dionella* exhibiting randomly distributed interzooecial avicularia. Mural rim with distinct spines; gymnocyst with small pores.

Description.--Zoarium membraniporiform, incrusting valves and fragments of *Gryphaea vesicularis*. Zooecia arranged in bifurcating and trifurcating rows radiating from ancestrula, those zooecia in adjacent rows alternating in position. Zooecial communication by a single distal and two pairs of lateral dietellae, all of them small.

Zooecia distinct, separated by wide, deep furrows; about one and a half times as long as wide; irregularly hexagonal; proximal and distal margins truncate to broadly rounded. Gymnocyst extends about one-fourth zooecial length from proximal margin; surface smooth, moderately convex, with one or more pores occurring sporadically and placed randomly. Mural rim thick, flaring, finely granular, with transverse crenulations and with six spines on distal margin. Cryptocyst narrow, finely granular, transversely crenulate, sloping steeply into opesia.

Opesia large, oval, wider proximally than distally,

without opesiular indentations.

Avicularia interzooecial, one-fourth to one-third as large as zooecia, elongate, irregularly distributed; rostrum directed distally, sharp, channeled; margins finely granular; cryptocyst narrow, sloping gently into opesia; opesia oval, without pivotal structure.

Ovicell occurring in fourth and later generations of zooecia, hyperstomial, bulbous, about one-third as long as zooecia, lying on gymnocyst of distal zooecium. Surface rarely preserved, imperforate, finely granular.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	8	0.54 mm	0.054 mm	0.47 - 0.60 mm
lz	8	0.35 mm	0.031 mm	0.31 - 0.41 mm
ho	8	0.33 mm	0.031 mm	0.28 - 0.36 mm
lo	8	0.20 mm	0.013 mm	0.17 - 0.22 mm
Lav	8	0.15 mm	0.022 mm	0.13 - 0.19 mm
lav	8	0.10 mm	0.020 mm	0.07 - 0.12 mm
Lov	8	0.16 mm	0.018 mm	0.15 - 0.19 mm
lov	8	0.14 mm	0.009 mm	0.13 - 0.15 mm

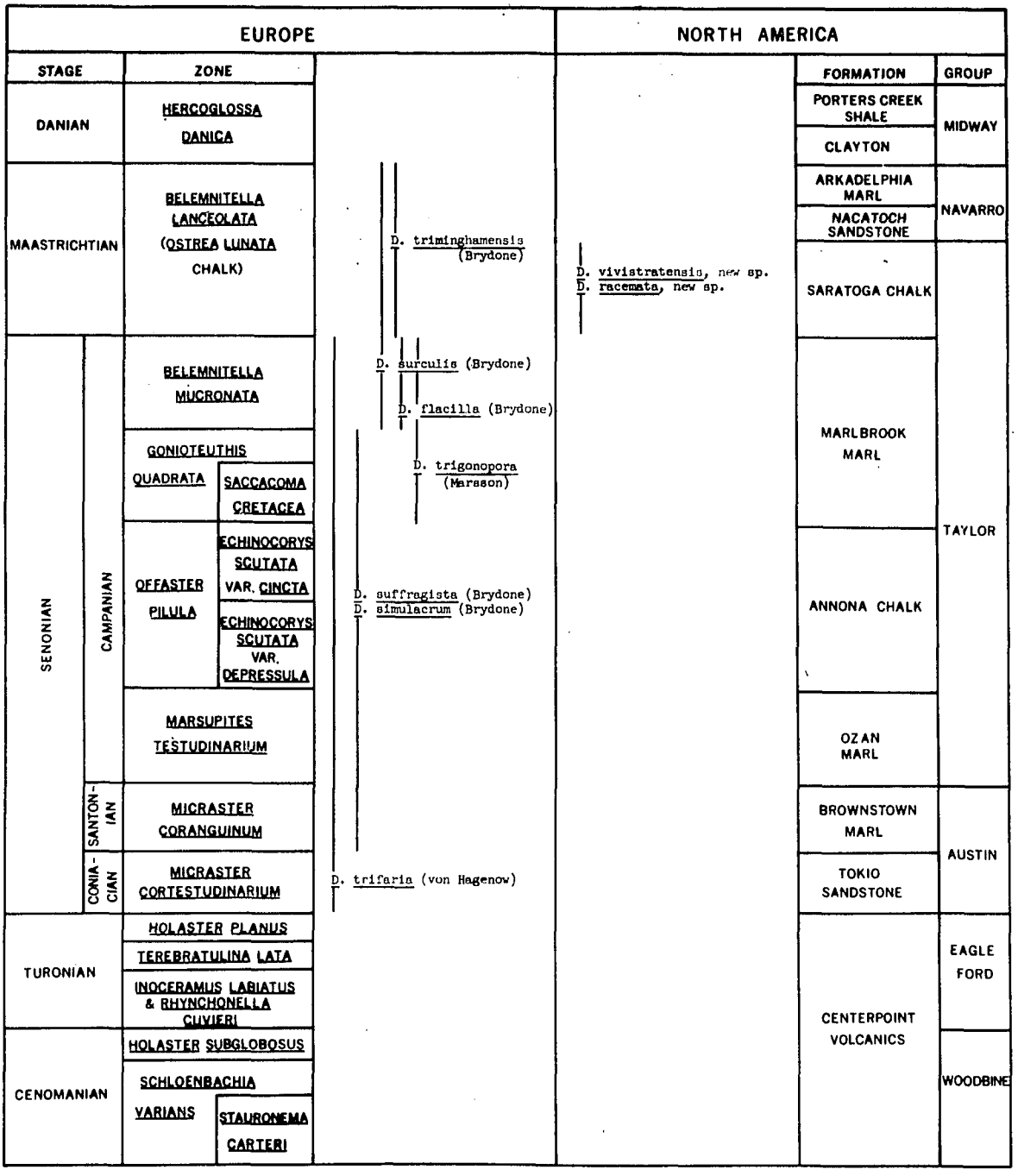
Occurrence.--Lowest unit of Saratoga Chalk, immediately above the Marlbrook Marl, in a bed of Gryphaea vesicularis, north edge of Saratoga, Arkansas. Locality AH-1.

Discussion.--Electra pilosa (Linnaeus) and Electra crustulenta (Pallas) have a large median spine on the proximal gymnocyst near the mural rim; if broken, the scar of this spine is very similar to the gymnocystal pores of D. vivistratensis and other species of Dionella, though generally closer to the mural rim. It seems likely, therefore, that these are different structures in the two genera.

According to Medd (1965, p. 515) the first species of Dionella to possess a gymnocystal pore is D. suffragista (Brydone) from the Uintacrinus socialis zone (Senonian) of Europe. Although D. vivistratensis is similar to D. suffragista in the possession of gymnocystal pores, it differs from the latter in the size and, in part, the number of pores and in having smaller zooecia. Also the gymnocystal pore in D. suffragista is elevated rather than depressed and there are eight distal spines on the mural rim of that species.

Though several species of Dionella have been reported from Senonian to Maastrichtian in Europe (Medd, 1965, p. 515), the genus has been known in North America only from the Jacksonian of North Carolina. D. vivistratensis occurs in rocks generally equivalent to those containing D. triminghamensis and D. surculis in Europe (Figure 10).

Fig. 10. Range chart of species of Dionella


EUROPE
NORTH AMERICA
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DANIAN
HERCOGLOSSA DANICA
PORTERS CREEK SHALE
CLAYTON
MIDWAY
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
MARSUPITES TESTUDINARIUM
SARATOGA CHALK
MARLBROOK MARL
ANNONA CHALK
OZAN MARL
TAYLOR
SANTONIAN
MICRASTER CORANGUINUM
CONIACIAN
MICRASTER CORTESTUDINARIUM
BROWNSTOWN MARL
TOKIO SANDSTONE
AUSTIN
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
CENTERPOINT VOLCANICS
EAGLE FORD
WOODBINE
D. triminghamensis (Brydone)
D. surculis (Brydone)
D. flacilla (Brydone)
D. trigonopora (Marsson)
D. suffragista (Brydone)
D. simulacrum (Brydone)
D. trifaria (von Hagenow)
D. vivistratensis, new sp.
D. racemata, new sp.

Dionella racemata, new species

Plate 2, figure 4

Etymology.--L., *racematus*, having clusters; referring to the clustering of the interzooecial avicularia.

Material.--Holotype 8240, Louisiana State University Geology Museum, a zoarial fragment incrusting *Gryphaea vesicularis*; paratypes 8266 and 8267, two additional zoarial fragments incrusting the same *Gryphaea*.

Diagnosis.--*Dionella* having irregularly hexagonal zooecia and numerous, distally-directed interzooecial avicularia; cryptocyst narrow; gymnocyst broad; mural rim spinose.

Description.--Zoarium membraniporiform, incrusting valves and fragments of *Gryphaea vesicularis*, zooecia in irregular, bifurcating rows emanating from ancestrula, those in adjacent rows alternating in position. Zooecial communication by small, indistinct, paired dietellae.

Zooecia distinct, separated by wide furrows, nearly hexagonal to pear-shaped, about half as wide as long; distal margin narrowly rounded; proximal margin narrow and truncate. Gymnocyst extends about one-third zooecial

length from proximal margin; surface moderately convex, finely pitted, granular, without pores. Mural rim salient, concentrically crenulated, flaring, finely granular, thickened proximally to form occasional spine-like median node; mural spines small, hollow, in 5 to 8 pairs around distal and lateral margins.

Cryptocyst slightly concave, imperforate, with fine concentric and transverse crenulations; widest proximally and merging with lateral mural rim distally; on many zooecia proximal portion depressed.

Opesia roughly bell-shaped, truncate to broadly rounded proximally, more narrowly rounded distally; opesiular indentations not differentiated.

Avicularia numerous, interzooecial and adventitious. Interzooecial avicularia inclined proximally with sharp rostrum directed distally, occurring in clusters of many as seven, usually at distal lateral margins of zooecia and sometimes placed on a kenozooecium of the same size as a normal zooecium; opening elliptical, without pivotal structure. Adventitious avicularia occur only on ovicells at middle of distal margin of about half of the ovicells; small, round, without pivotal structure.

Ovicell hyperstomial, bulbous, slightly larger than wide, imperforate, finely granular, with median longitudinal ridge; orifice semicircular, with smooth, raised lip. Ovicells occur in the fifth and succeeding generations.

Measurements:--

	No.	Mean	Std. Dev.	Observed Range
Lz	10	0.30 mm	0.096 mm	0.24 - 0.36 mm
lz	10	0.16 mm	0.005 mm	0.15 - 0.19 mm
ho	10	0.23 mm	0.004 mm	0.15 - 0.28 mm
lo	10	0.13 mm	0.005 mm	0.11 - 0.15 mm
Lov	10	0.14 mm	0.029 mm	0.13 - 0.15 mm
lov	10	0.13 mm	0.004 mm	0.11 - 0.14 mm
Lav	10	0.17 mm	0.012 mm	0.06 - 0.19 mm)
lav	10	0.05 mm	0.009 mm	0.05 - 0.06 mm) Interzooecial avicularia)
Lav	10	0.03 mm	0.005 mm	0.02 - 0.04 mm)
lav	10	0.003 mm	0.003 mm	0.02 - 0.03 mm) adventitious avicularia

Occurrence.--Lowest unit of the Saratoga Chalk, Taylor Group, in a shell hash of Gryphaea vesicularis, immediately overlying the Marlbrook Marl, at the type locality of the Saratoga Chalk. Locality AH-1.

Discussion.--Dionella racemata differs from D. triminghamensis

(Brydone) in having smaller dimensions and an avicularium on the ovicell. The two species are similar in their well-developed gymnocysts and the numerous spines. The obsolescent dietellae of Dionella racemata are similar to those of D. trigonopora (Marsson).

Family Microporidae Gray, 1848

Genus Micropora Gray, 1848

Micropora (?) sp.

Plate 3, figure 3

Material.--Figured specimen 8251, Louisiana State University Geology Museum, a zoarial fragment consisting of ten incomplete zooecia.

Description.--Zoarium membraniporiform, incrusting Gryphaea vesicularis, with zooecia in bifurcating rows, those in adjacent rows alternating in position. Interzooecial communication by large dietellae, a single one at distal margin and two pairs on lateral margins.

Zooecia distinct, separated by shallow furrows; hexagonal, nearly as wide as long; distal and proximal margins sharply truncate, lateral margins angular. Mural rim salient, finely granular. Gymnocyst lacking. Cryptocyst complete,

finely granular, depressed near center of zooecium; opesiular indentations or opesiules not evident.

Opesia terminal, semicircular, surrounded by raised margin supporting five to seven oral spines distally.

Avicularia and ovicell unknown.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	4	0.54 mm	0.046 mm	0.49 - 0.60 mm
lz	4	0.47 mm	0.014 mm	0.45 - 0.48 mm
ho	4	0.31 mm	0.050 mm	0.26 - 0.36 mm
lo	4	0.33 mm	0.032 mm	0.30 - 0.37 mm

Occurrence.--Immediately above the Marlbrook Marl in the lowest unit of the Saratoga Chalk, a biostrome of Gryphaea vesicularis. Locality AH-1.

Discussion.--Micropora (?) sp. differs from M. stevensis Levinsen, from the Danian of Denmark, in having wider zooecia and in lacking ovicells; the two species are similar in lacking opesiules, an unusual phenomenon in Micropora.

The fragmentary state of all the zooecia in four zoaria of this species makes precise generic or specific assignment impossible. In only one zooecium is sufficient cryptocyst present to prove the absence of opesiules.

Distribution of Cretaceous species of Micropora is shown in Figure 11. M. glabra has a similar range to M. (?) sp.

Cheethamia, new genus

Type species.--Cheethamia howei, new species. Saratoga Chalk, Arkansas.

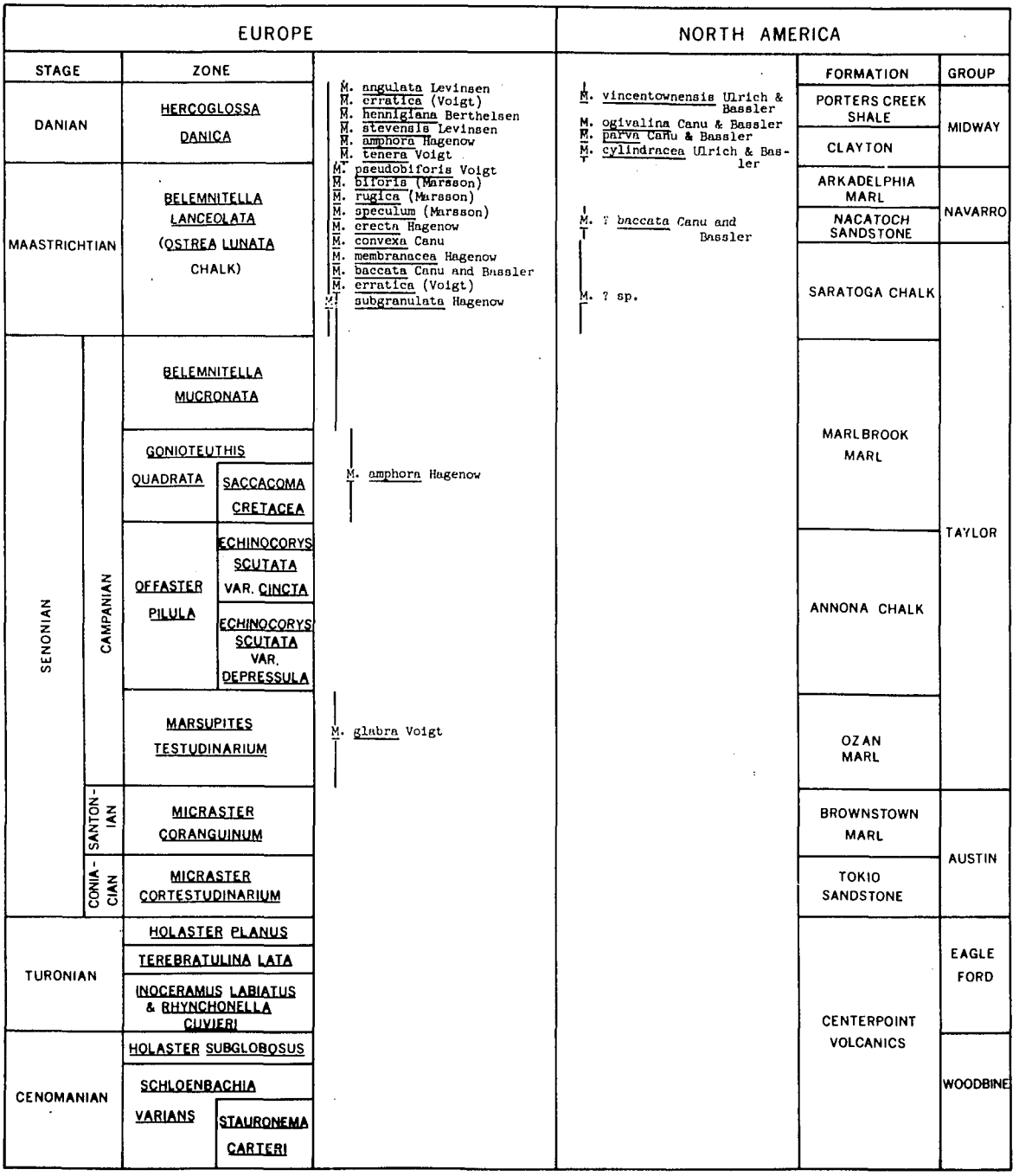
Etymology.--Named in honor of Alan H. Cheetham.

Diagnosis.--Frontal wall without gymnocyst, underlain by an extensive, imperforate cryptocyst; opesia terminal on cryptocyst, semicircular, with shallow, slit-like opesiular indentations at proximolateral corners; avicularia vicarious, lancehead-shaped, with pointed, channeled rostrum and simple opesia; ovicell hyperstomial, imperforate; zoarium incrusting.

Range.--Maastrichtian, Arkansas, Crimea, Denmark, and the Low Countries.

Discussion.--In addition to the type species this genus includes Membranipora nodulifera Levinsen (1925, p. 350, pl. 4, fig. 44) from the Maastrichtian of Moen and Aalborg,

Fig. 11. Range chart of species of Micropora (?)


EUROPE
NORTH AMERICA
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GROUP
DANIAN
HERCOGLOSSA DANICA
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SACCACOMA CRETACEA
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ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
MARSUPITES TESTUDINARIUM
SANTONIAN
MICRASTER CORANGUINUM
CONIACIAN
MICRASTER CORTESTUDINARIUM
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
M. angulata Levinsen
M. erratica (Voigt)
M. hennigiana Berthelsen
M. stevensis Levinsen
M. amphora Hagenow
M. tenera Voigt
M. pseudobiforis Voigt
M. biforis (Marsson)
M. rugica (Marsson)
M. speculum (Marsson)
M. erecta Hagenow
M. convexa Canu
M. membranacea Hagenow
M. baccata Canu and Bassler
M. erratica (Voigt)
M. subgranulata Hagenow
M. amphora Hagenow
M. glabra Voigt
M. vincentownensis Ulrich & Bassler
M. ogivalina Canu & Bassler
M. parva Canu & Bassler
M. cylindracea Ulrich & Bassler
M. ? baccata Canu and Bassler
M. ? sp.
PORTERS CREEK SHALE
CLAYTON
MIDWAY
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
MARLBROOK MARL
ANNONA CHALK
OZAN MARL
TAYLOR
BROWNSTOWN MARL
TOKIO SANDSTONE
AUSTIN
CENTERPOINT VOLCANICS
EAGLE FORD
WOODBINE

Denmark, and of Belgium and Holland, which Voigt (1957, p. 350) referred to Onychocella Jullien, and Onychocella pinquis Voigt (1962, p. 45) from the Maastrichtian of the Crimea. Onychocella differs from Cheethamia in having onychocellarian avicularia, endozooecial ovicells, and the opesia usually somewhat removed from the distal margin of the cryptocyst (see Cheetham, 1966, p. 31) and with larger, less differentiated opesiular indentations. These differences are great enough to make it very unlikely that Cheethamia and Onychocella belong to the same family.

Cheethamia differs from Rosseliana Jullien, a microporid genus, chiefly in having avicularia. From other microporids, e.g. Micropora Hincks and Microporina Levinsen, Cheethamia differs in lacking opesiules separate from the opesia.

Cheethamia appears to be restricted to the Maastrichtian in both Europe and North America (Figure 12).

Cheethamia howei, new species

Plate 3, figure 4

Etymology.--Named in honor of H. V. Howe.

Material.--Holotype 8237, Louisiana State University Geology

Museum, a zoarial fragment consisting of 162 complete zooecia and other broken and masked zooecia.

Diagnosis.--The only species of Cheethamia known in the U.S.

Description.--Zoarium membraniporiform, incrusting valves of Gryphaea vesicularis; zooecia in bifurcating and trifurcating rows, those in adjacent rows alternating in position.

Zooecia distinct, separated by salient mural rims, slightly longer than wide, irregularly hexagonal; distal margin rounded; proximal margin truncate. Mural rim salient, narrow, finely granular, coinciding with zooecial outline. Gymnocyst lacking.

Cryptocyst extends two-thirds zooecial length from proximal margin, depressed below mural rim but slightly convex, imperforate, finely granular, doming upward around opesia.

Opesia terminal, rounded distally, straight or slightly concave proximally; opesiular indentations shallow, narrow, almost silt-like, placed at proximolateral corners of opesia.

Avicularium interzooecial, about as long as zooecia but only half as wide; beak directed distally, sharp, channeled, with flaring, wing-like margins, one-half length of

avicularium, cryptocyst concave, finely granular; proximal margin triangular; opesia small, central, circular, without opesiular indentations or opesiules.

Ovicell hyperstomial, finely granular, bulbous; about as wide as long; orifice triangular, with slightly flaring lip.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	10	0.66 mm	0.096 mm	0.57 - 0.74 mm
lz	10	0.51 mm	0.005 mm	0.48 - 0.54 mm
ho	10	0.14 mm	0.018 mm	0.12 - 0.17 mm
lo	10	0.15 mm	0.018 mm	0.14 - 0.19 mm
Lav	10	0.62 mm	0.060 mm	0.48 - 0.68 mm
lav	10	0.23 mm	0.050 mm	0.14 - 0.31 mm
Lov	10	0.23 mm	0.034 mm	0.19 - 0.27 mm
lov	10	0.23 mm	0.034 mm	0.17 - 0.26 mm

Occurrence.--Lowest unit, consisting of shell fragments of Gryphaea vesicularis, of the Saratoga Chalk, immediately overlying the Marlbrook Marl. Locality AH-1.

Discussion.--C. howei is similar to C. pinquis (Voigt) especially in its cryptocyst and avicularia. The zooecial dimensions of the latter species are slightly greater, its avicularia are wider, and its ovicell is less bulbous and

perhaps immersed in the distal zooecium, though described by Voigt (1962, p. 45) as hyperstomial.

C. howei differs from C. nodulifera (Levinsen) in the absence of a "rounded knob-shaped thickening in the uppermost part of the aperture" and in the more proximal extension of its opesia.

C. howei occurs at a stratigraphic level apparently equivalent to that from which the European species have been described (Figure 12).

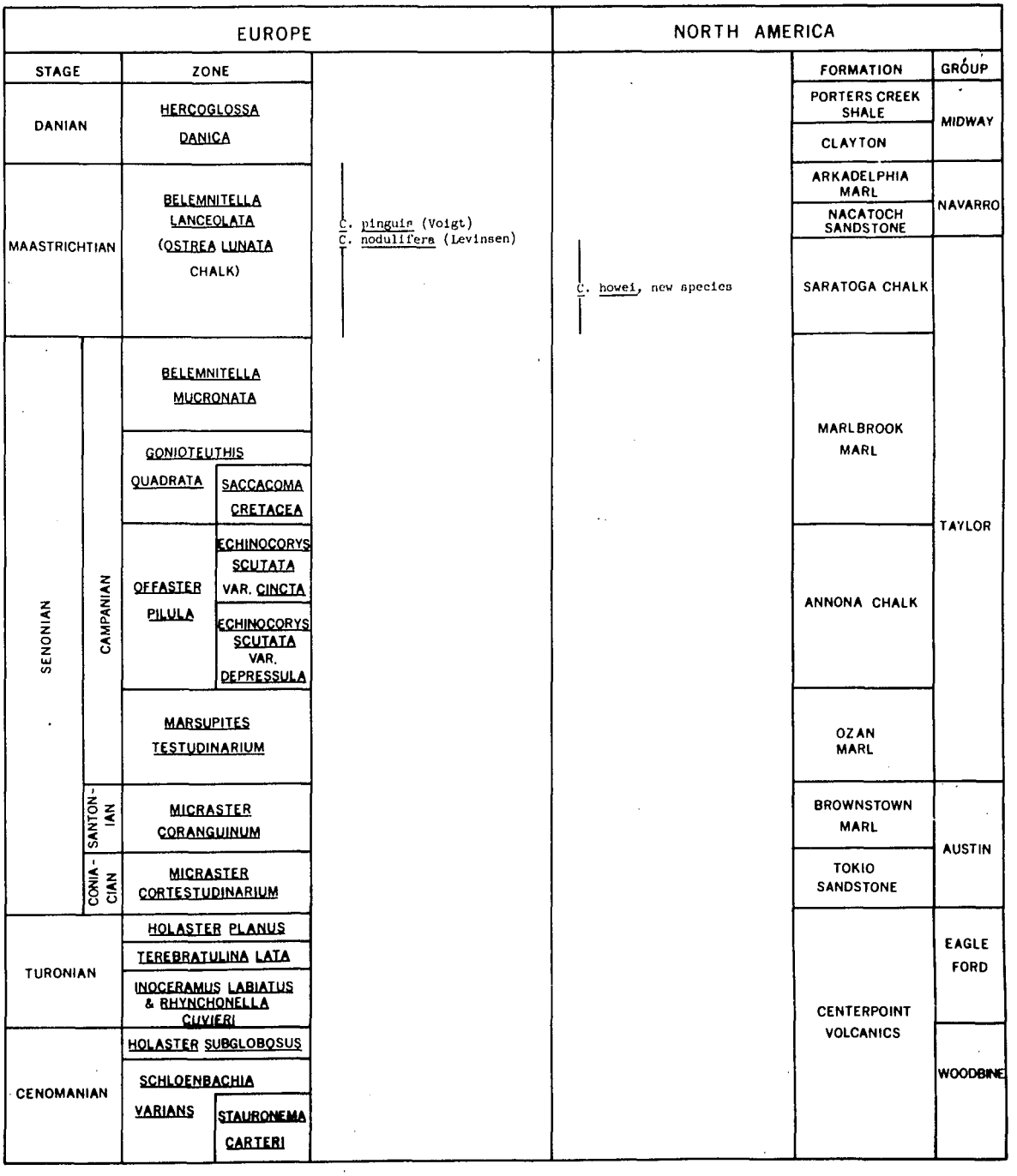
Genus Aechmella Canu and Bassler, 1917

Aechmella Canu and Bassler, 1917, p. 29.

Type species.--Aechmella filimargo Canu and Bassler, 1917, p. 29, pl. 3, fig. 5. Eocene (Upper Jacksonian), Alabama.

Discussion.--Aechmella was established by Canu and Bassler (1917, p. 29; 1920, p. 233) for two species from the Jacksonian of the southeastern United States. Voigt (1962, p. 39) and Berthelsen (1962, p. 138) have since described species of this genus and transferred previously described species into it; a total of 17 species is now known from the Upper Cretaceous and Danian of Europe (Figure 13).

Fig. 12. Range chart of species of Cheethamia


EUROPE
NORTH AMERICA
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MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
C. pinguis (Voigt)
C. nodulifera (Levinsen)
C. howei, new species
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
MARLBROOK MARL
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
ANNONA CHALK
TAYLOR
MARSUPITES TESTUDINARIUM
OZAN MARL
SANTONIAN
MICRASTER CORANGUINUM
BROWNSTOWN MARL
CONIACIAN
MICRASTER CORTESTUDINARIUM
TOKIO SANDSTONE
AUSTIN
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
CENTERPOINT VOLCANICS
EAGLE FORD
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
WOODBINE

A. ozanensis, new species, is the first American Cretaceous species known.

Aechmella differs from Floridina Jullien (Family Onychocellidae) in the form of the avicularium and zooecial opesia.

Aechmella ozanensis, new species

Plate 3, figure 2

Etymology.--After the Ozan Formation in which it occurs.

Material.--Holotype 8241, Louisiana State University Geology Museum, a zoarial fragment consisting of four complete zooecia; paratype 8268.

Diagnosis.--Erect Aechmella having small zooecia and large avicularia, which produce a "nuclear effect" on zooecial rows.

Description.--Zoarium erect, unilaminar, with zooecia arranged in few, irregular rows; avicularia produce "nuclear effect" on zooecial rows, i.e., the two proximal zooecia diverge and the two distal zooecia converge around each avicularium.

Zooecia distinct, separated by their mural rims, almost as wide as long; irregularly hexagonal to slightly asymmetrical because of the "nuclear effect"; distal margin

broadly rounded; proximal margin narrow and truncate. Mural rim salient, broadly rounded, finely granular, pronounced distally, merging proximally with cryptocyst. Gymnocyst lacking. Cryptocyst imperforate, granular, sloping steeply distally to proximal lip of opesia and merging distally with mural rim.

Opesia terminal, rounded distally, straight proximally; distal margin formed by hood-like mural rim; proximal margin without rim. Opesiular indentations barely discernible, small, shallow, slit-like.

Avicularia vicarious, nearly as long as, but narrower than zooecia, lozenge-shaped. Rostrum sharp, channeled, flaring; cryptocyst finely granular; opesia elliptical, without opesiules, indentations on pivotal structure.

Ovicells lacking.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	8	0.43 mm	0.004 mm	0.38 - 0.45 mm
lz	8	0.34 mm	0.038 mm	0.28 - 0.38 mm
ho	7	0.14 mm	0.019 mm	0.12 - 0.15 mm
lo	7	0.13 mm	0.012 mm	0.12 - 0.15 mm
Lav	7	0.34 mm	0.040 mm	0.28 - 0.38 mm
lav	7	0.12 mm	0.012 mm	0.11 - 0.14 mm

Occurrence.--Two inches below the Ozan-Annona contact in the Ozan Formation, in a soft marl at White Cliffs Station, Arkansas. Locality AS-5.

Discussion.--This species differs from A. pindborgi Berthelsen, from the Danian of Denmark, in possessing larger avicularia, and an approximately equidimensional opesia.

A. anglica (Brydone), a widespread Senonian-Danian species in Europe, differs from A. ozanensis in having larger zooecia and smaller avicularia (Voigt, 1949, p. 29).

Although Aechmella is common in the Cretaceous of Europe, it is rare in North America. Only the single American Cretaceous species, A. ozanensis, represented by two zoaria, is known. A. ozanensis occurs at a lower stratigraphic level than any of the European species except A. michaudiana (d'Orbigny) (Figure 13).

Suborder Acanthostega Levinsen, 1902

Family Pelmatoporidae Lang, 1916

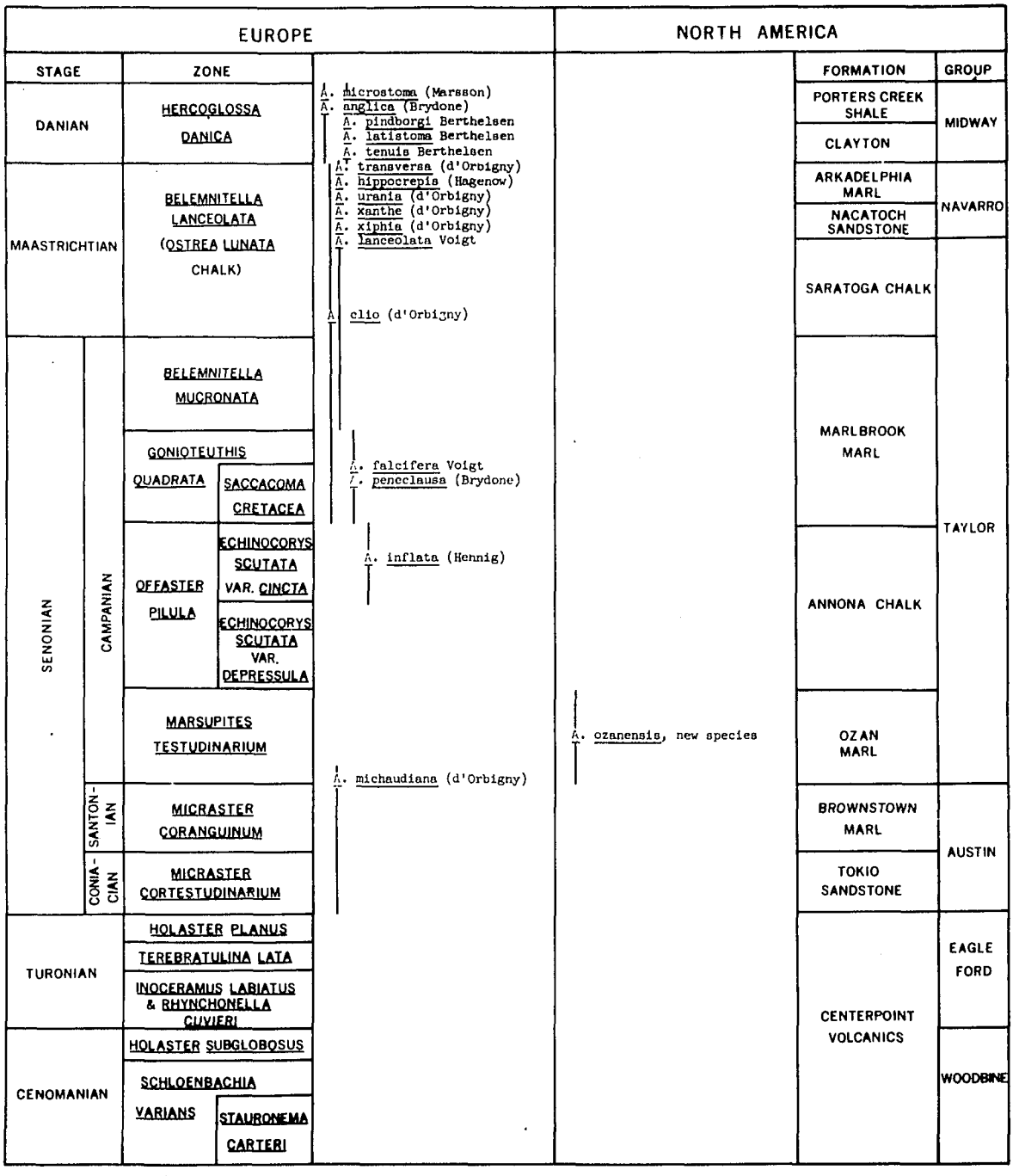
Subfamily Pelmatoporinae Lang, 1916

Genus Castanopora Lang, 1916

Castanopora spooneri (Butler and Cheetham), 1958

Plate 4, figure 1

Fig. 13. Range chart of species of Aechmella


EUROPE
NORTH AMERICA
STAGE
ZONE
FORMATION
GROUP
DANIAN
HERCOGLOSSA DANICA
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
MARSUPITES TESTUDINARIUM
SANTONIAN
MICRASTER CORANGUINUM
CONIACIAN
MICRASTER CORTESTUDINARIUM
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
A. microstoma (Marsson)
A. anglica (Brydone)
A. pindborgi Berthelsen
A. latistoma Berthelsen
A. tenuis Berthelsen
A. transversa (d'Orbigny)
A. hippocrepis (Hagenow)
A. urania (d'Orbigny)
A. xanthe (d'Orbigny)
A. xiphia (d'Orbigny)
A. lanceolata Voigt
A. clio (d'Orbigny)
A. falcifera Voigt
A. peneclausa (Brydone)
A. inflata (Hennig)
A. michaudiana (d'Orbigny)
A. ozanensis, new species
PORTERS CREEK SHALE
CLAYTON
MIDWAY
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
MARLBROOK MARL
ANNONA CHALK
OZAN MARL
TAYLOR
BROWNSTOWN MARL
TOKIO SANDSTONE
AUSTIN
CENTERPOINT VOLCANICS
EAGLE FORD
WOODBINE

Rhiniopora spooneri Butler and Cheetham, 1958, p. 1153, text-figs. 1, 2.

Castanopora spooneri (Butler and Cheetham); Larwood, 1962, p. 220.

Material.--Figures specimen 8273, Louisiana State University Geology Museum, a zoarial fragment consisting of 17 complete zooecia. Additional zoarial fragments studied, but not catalogued.

Diagnosis.--Castanopora having small, elliptical zooecia with 13-16 costae and small, monomorphic, distally-directed avicularia.

Description.--Zoarium membraniporiform, incrusting shell fragments of Gryphaea vesicularis; zooecia in bifurcating rows radiating from ancestrula, those in adjacent rows alternating in position.

Zooecia distinct, separated by furrows between contiguous costal shields; irregularly elliptical; slightly longer than wide; distal and proximal margins rounded; lateral margins broadly curved. Gymnocyst lacking. Frontal shield convex, consisting of 13-16 costae excluding apertural bar; median area of fusion narrow, elongate, inconspicuous beneath

inner ends of costae. Costae distinct, narrow, extending from zooecial margins to midline of median area of fusion; each costa with 4-6 inconspicuous pelmatidia; adjacent costae separated by 4-6 lateral costal fusions forming 5-7 small lacunae.

Orifice semicircular to cribriline, with arched distal margin supporting 4-5 spine bases in normal zooecia, two in ovicelled ones; proximal margin concave with enlarged apertural bar, curved, finely granular, without pelmatidia, but with a median process.

Avicularia interzooecial, monomorphic, directed distally, lying distal or distolateral to zooecia without ovicells; small, oval; rostrum pointed; pivotal structure lacking.

Ovicell hyperstomial, bulbous, imperforate, finely granular, about half as wide as long, with median, broadly rounded, salient ridge; orifice small, with raised margin.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	10	0.34 mm	0.030 mm	0.30 - 0.38 mm
lz	10	0.30 mm	0.034 mm	0.26 - 0.36 mm
ho	10	0.07 mm	0.008 mm	0.06 - 0.08 mm
lo	10	0.08 mm	0.006 mm	0.08 - 0.09 mm

	No.	Mean	Std. Dev.	Observed Range
Lov	4	0.15 mm	0.022 mm	0.14 - 0.19 mm
lov	4	0.14 mm	0.073 mm	0.14 - 0.15 mm
Lav	10	0.10 mm	0.010 mm	0.08 - 0.11 mm
lav	10	0.06 mm	0.010 mm	0.05 - 0.18 mm

Occurrence.--Lowest unit of Saratoga Chalk, Taylor Group, in a shell hash of Gryphaea vesicularis, immediately overlying the Marlbrook Marl, at the type locality of the Saratoga Chalk. Locality AH-1.

Discussion.--This species was described by Butler and Cheetham (1958, p. 1153) as Rhiniopora spooneri from the Saratoga Chalk equivalent exposed at Rayburn's Dome in north-central Louisiana. The characters of the specimens from the Saratoga Chalk of Arkansas are virtually the same as those of the type specimens. In the original description, Butler and Cheetham included the apertural bar in the count of costae, so that the range of 14 to 18 given by them is not directly comparable with the ranges given here and in Larwood's (1962) diagnosis.

Larwood (1962, p. 220) transferred R. spooneri to Castanopora by combining Rhiniopora Lang with Castanopora; his assignment is followed here, though the zooecial size

and costal number are considerably lower than in other species.

Castanopora is common in the Campanian, Maastrichtian, and Danian of Europe, represented by no fewer than 14 species (Figure 14). The single species from the Saratoga Chalk and two species from the Vincentown Marl of New Jersey form the entire known record of the genus in North America.

The difference between C. spooneri and other species of the genus have been adequately enumerated by Larwood (1962, p. 220).

Subfamily Tricephaloporinae Lang, 1922

Genus Tricephalopora, Lang, 1916

Tricephalopora larwoodi, new species

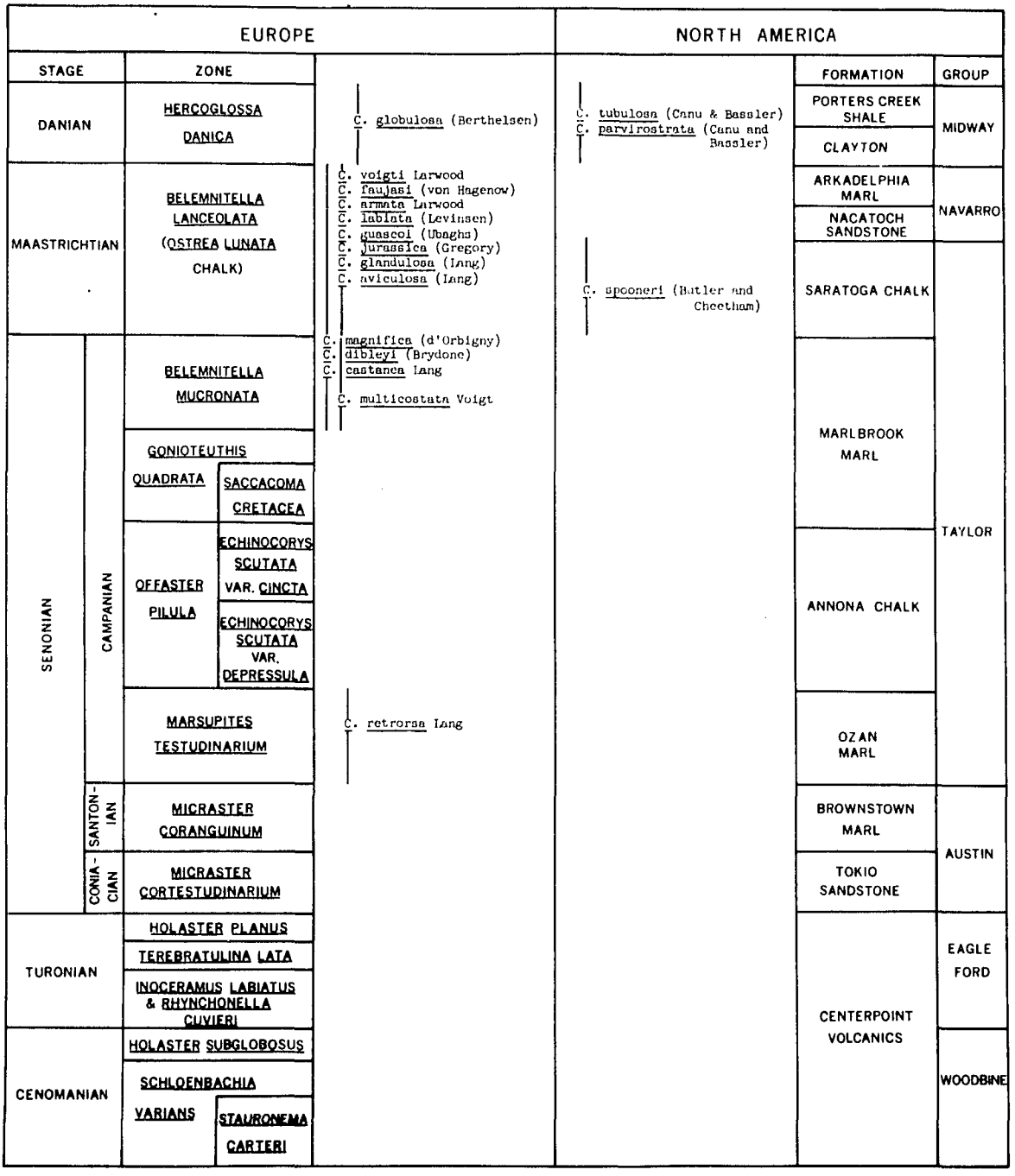
Plate 4, figure 2

Etymology.--Named in honor of Gilbert P. Larwood.

Material.--Holotype 8242, Louisiana State University Geology Museum, a zoarial fragment consisting of 62 complete zooecia.

Diagnosis.--Tricephalopora having 11-14 costae forming a large frontal shield with small median area of fusion; peristome with a single, median pore in about half the zooecia;

Fig. 14. Range chart of species of Castanopora


EUROPE
NORTH AMERICA
STAGE
ZONE
FORMATION
GROUP
DANIAN
HERCOGLOSSA DANICA
C. globulosa (Berthelsen)
C. tubulosa (Canu & Bassler)
C. parvirostrata (Canu and Bassler)
PORTERS CREEK SHALE
CLAYTON
MIDWAY
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
C. voigti Larwood
C. faujasi (von Hagenow)
C. armata Larwood
C. labinta (Levinsen)
C. guascoi (Ubaghs)
C. jurassica (Gregory)
C. glandulosa (Lang)
C. aviculosa (Lang)
C. spooneri (Butler and Cheetham)
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
C. magnifica (d'Orbigny)
C. dibleyi (Brydone)
C. castanea Lang
C. multicostata Voigt
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
MARLBROOK MARL
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
ANNONA CHALK
MARSUPITES TESTUDINARIUM
C. retrorsa Lang
OZAN MARL
TAYLOR
SANTONIAN
MICRASTER CORANGUINUM
BROWNSTOWN MARL
CONIACIAN
MICRASTER CORTESTUDINARIUM
TOKIO SANDSTONE
AUSTIN
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
CENTERPOINT VOLCANICS
EAGLE FORD
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
WOODBINE

and regularly paired lateral oral avicularia, directed inward.

Description.--Zoarium membraniporiform, incrusting valves and fragments of Gryphaea vesicularis; zooecia in irregular bifurcating rows radiating from ancestrula, those in adjacent rows alternating in position.

Zooecia distinct, separated by shallow depression between contiguous gymnocysts, irregularly oval, slightly over half as wide as long, widest near distal end. Gymnocyst narrow, finely granular, extending from proximal margin along lateral margins to peristome with which it merges.

Frontal shield broadly convex, consisting of 11-14 costae (excluding apertural bar) radiating laterally and proximally from median area of fusion; costae distinct, straight, narrow, without pelmata; lacunae slit-like, undivided by lateral costal fusions.

Primary orifice subcircular to semicircular, rounded distally, straight or rounded proximally, partially hidden at base of thick, elongate peristome. Secondary orifice circular, elliptical or semicircular. Apertural bar completely covered by peristome except on about half the zooecia

where a single, large, median pore separates it from the proximal part of peristome.

Avicularia adventitious, paired, one on each side of peristome, lateral to secondary orifice, triangular, directed inward; opening oval, divided by pivotal bar; beak channeled, pointed.

Ovicell hyperstomial, globular, about half as long as wide, opening into peristome, slightly overlapping frontal wall of distal zooecium; surface imperforate, finely granular.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	10	0.45 mm	0.040 mm	0.40 - 0.54 mm
lz	10	0.25 mm	0.026 mm	0.22 - 0.28 mm
ho	10	0.09 mm	0.019 mm	0.07 - 0.12 mm
lo	10	0.11 mm	0.005 mm	0.09 - 0.14 mm
Lov	10	0.07 mm	0.018 mm	0.05 - 0.11 mm
lov	10	0.12 mm	0.015 mm	0.05 - 0.15 mm
Lav	10	0.12 mm	0.022 mm	0.09 - 0.15 mm
lav	10	0.11 mm	0.017 mm	0.08 - 0.13 mm

Occurrence.--Chalk bed with abundant Gryphaea vesicularis, in the Saratoga Chalk and immediately overlying the Marlbrook Marl, at the type locality of the Saratoga Chalk.

Locality AH-1.

Discussion.--Twenty-five species of Tricephalopora have been described from the Upper Cretaceous (Coniacian-Maastrichtian) and Danian of Europe (Figure 15). Three species only, all from the Vincentown Marl of New Jersey, have been known hitherto from North America. According to Lang (1922, p. 51-54), trends in Tricephalopora include (1) development of regularly paired avicularia near the proximolateral corners of the secondary orifice, (2) development on the peristome of a median proximal pore which, in some advanced forms such as T. triceps, may be filled with secondary material leaving a depression, and (3) increase in zooecial size. T. larwoodi displays intermediate characters in having (1) regularly paired avicularia, (2) median pores on some zooecia but not others, and (3) small zooecia. T. larwoodi resembles the Danian species T. subtriceps Berthelsen and the Vincentown species T. acutirostris Canu and Bassler more than any others; from the former it differs in having smaller zooecia and from the latter in having more costae.

Tricephalopora arkansasensis, new species

Plate 4, figure 4

Etymology--Named for Arkansas in which its type locality lies.

Material.--Holotype 8243, Louisiana State University Geology Museum, a zoarial fragment with 22 complete zooecia and 14 incomplete zooecia.

Diagnosis.--Tricephalopora with 12-18 costae forming large frontal shield with broad median area of fusion; peristome lacking pores; avicularium lateral on gymnocyst, lapping onto peristome of laterally adjacent zooecium.

Description.--Zoarium membraniporiform, incrusting valves of Gryphaea vesicularis, with zooecia in irregular bifurcating rows radiating from the ancestrula, those in adjacent rows alternating in position.

Zooecia distinct, separated by a shallow depression (sometimes by a wide furrow) between contiguous gymnocysts; irregularly oval, more than twice as long as wide; rounded both distally and proximally; laterally straight to broadly rounded. Gymnocyst narrow, finely granular, with slight

crenulations.

Frontal shield depressed, composed of 12-18 costae (excluding apertural bar) radiating from broad, slightly convex, median area of fusion. Costae distinct, narrow, straight, without pelmata; lacunae slit-like, undivided by lateral costal fusions.

Primary orifice large, circular to transversely elliptical, surrounded by long, oblique peristome extending half the length of zooecium, without proximal pore. Secondary orifice large, circular to elliptical. Apertural bar completely covered by peristome.

Avicularium adventitious, single, placed on lateral gymnocyst, with rostrum directed laterally and proximally onto peristome of laterally adjacent zooecium. Rostrum sharp; opening with cross-bar.

Ovicell unknown.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	10	0.73 mm	0.039 mm	0.66 - 0.80 mm
lz	10	0.30 mm	0.028 mm	0.23 - 0.33 mm
ho	10	0.14 mm	0.013 mm	0.12 - 0.15 mm
lo	10	0.14 mm	0.013 mm	0.12 - 0.15 mm
Lav	7	0.13 mm	0.021 mm	0.12 - 0.17 mm
lav	7	0.09 mm	0.027 mm	0.07 - 0.12 mm

Occurrence.--Lowest chalk unit of Saratoga Chalk, immediately overlying the Marlbrook Marl at the north edge of Saratoga, Arkansas, at the type locality. Locality AH-1.

Discussion.--T. arkansasensis is most similar to T. circumvallata (Levinsen), from the Danian of Denmark, but differs in having single, not paired avicularia, and in having larger zooecia.

Subfamily Diacanthoporinae Lang, 1922

Genus Diacanthopora Lang, 1922

Diacanthopora langi, new species

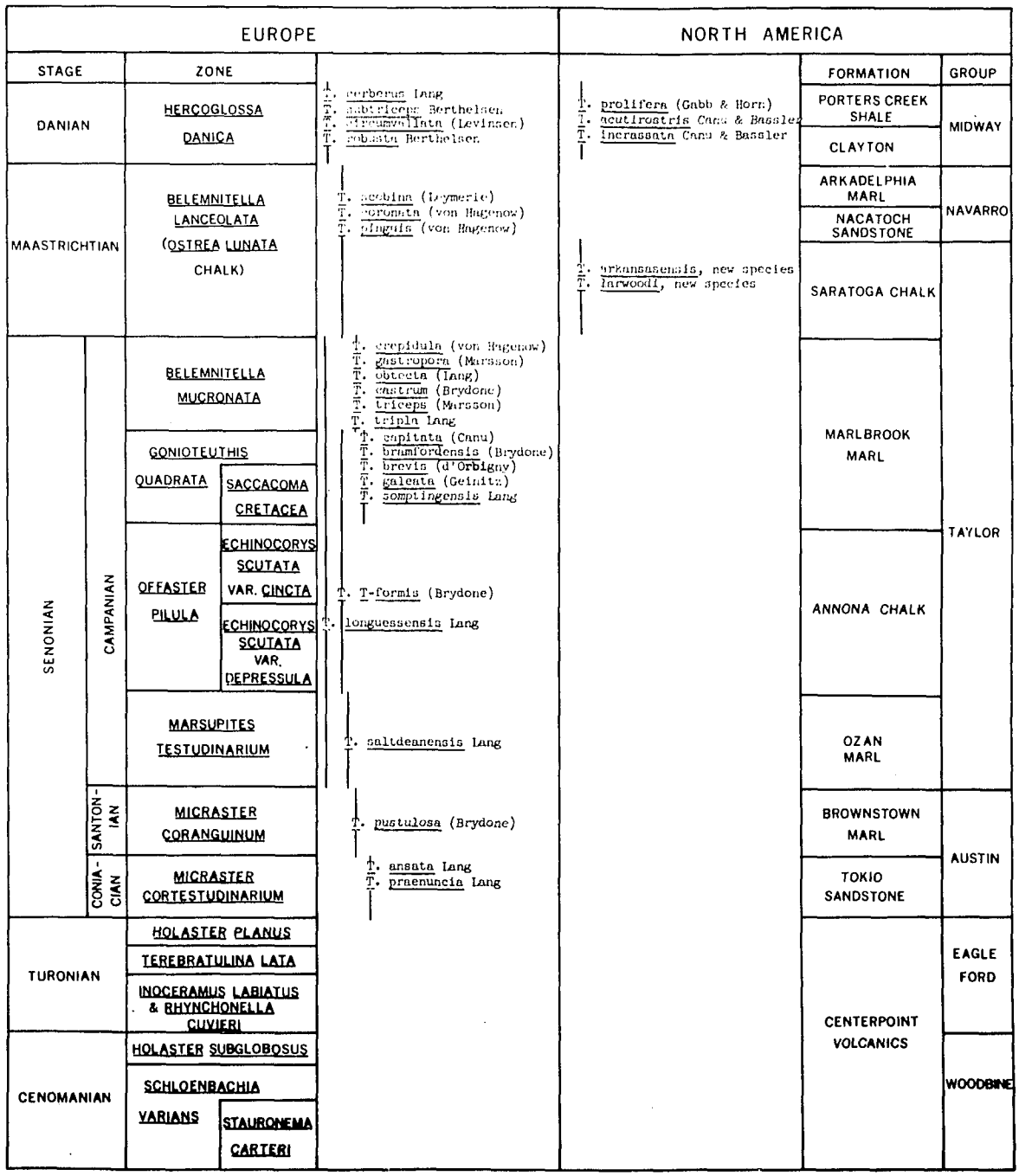
Plate 4, figure 3

Etymology.--Named in honor of W. D. Lang.

Material.--Holotype 8244, Louisiana State University Geology Museum, a zoarial fragment with five complete and six incomplete zooecia.

Diagnosis.--Diacanthopora having membraniporiform zoarium, zooecia of intermediate size with 14-16 costae and lacking secondary calcification.

Fig. 15. Range chart of species of Tricephalopora


EUROPE
NORTH AMERICA
STAGE
ZONE
FORMATION
GROUP
DANIAN
HERCOGLOSSA DANICA
T. cerberus Lang
T. subtricera Berthelsen
T. circumvallata (Levinsen)
T. robusta Berthelsen
T. prolifera (Gabb & Horn)
T. acutirostris Cann & Bassler
T. incrassata Cann & Bassler
PORTERS CREEK SHALE
CLAYTON
MIDWAY
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
T. scabina (Leymerie)
T. coronata (von Hagenow)
T. plenus (von Hagenow)
T. arkansasensis, new species
T. larwoodi, new species
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
T. crepidula (von Hagenow)
T. gastropora (Marsson)
T. obtecta (Lang)
T. castrum (Brydone)
T. triceps (Marsson)
T. tripla Lang
MARLBROOK MARL
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
T. capitata (Canu)
T. brumfordensis (Brydone)
T. brevis (d'Orbigny)
T. galeata (Geinitz)
T. somptingensis Lang
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
T. T-formis (Brydone)
ECHINOCORYS SCUTATA VAR. DEPRESSULA
T. longuessensis Lang
ANNONA CHALK
TAYLOR
MARSUPITES TESTUDINARIUM
T. saltdeanensis Lang
OZAN MARL
SANTONIAN
MICRASTER CORANGUINUM
T. pustulosa (Brydone)
BROWNSTOWN MARL
AUSTIN
CONIACIAN
MICRASTER CORTESTUDINARIUM
T. ansata Lang
T. praenuncia Lang
TOKIO SANDSTONE
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
EAGLE FORD
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
CENTERPOINT VOLCANICS
WOODBINE

Description.--Zoarium membraniporiform, incrusting valves of Gryphaea vesicularis and shell fragments; zooecia radiating outward from ancestrula in bifurcating, irregular rows, the zooecia in adjacent rows alternating in position.

Zooecia distinct, separated by shallow grooves between narrow gymnocystal borders; about two-thirds as wide as long; irregularly hexagonal; distal and proximal margins broadly rounded. Frontal shield with 14-16 costae (excluding apertural bar) radiating from finely granular, elongate, median area of fusion; costae flat to broadly convex, about as wide as long, each with two pelmata, the larger one on the outer end, the smaller on the inner end; lacunae elongate, slit-like, not divided by lateral costal fusions.

Orifice large, terminal, circular to subnormal, with raised distal border and a thick, smooth, simple apertural bar lacking pelmata. Oral spines lacking.

Avicularia adventitious, paired, one on each side of orifice; rostrum rounded, directed distally; pivotal structures lacking.

Ovicell hyperstomial, bulbous, finely granular, imperforate, about one-third length of zooecium, wider than long, with small orifice.

Measurements.--

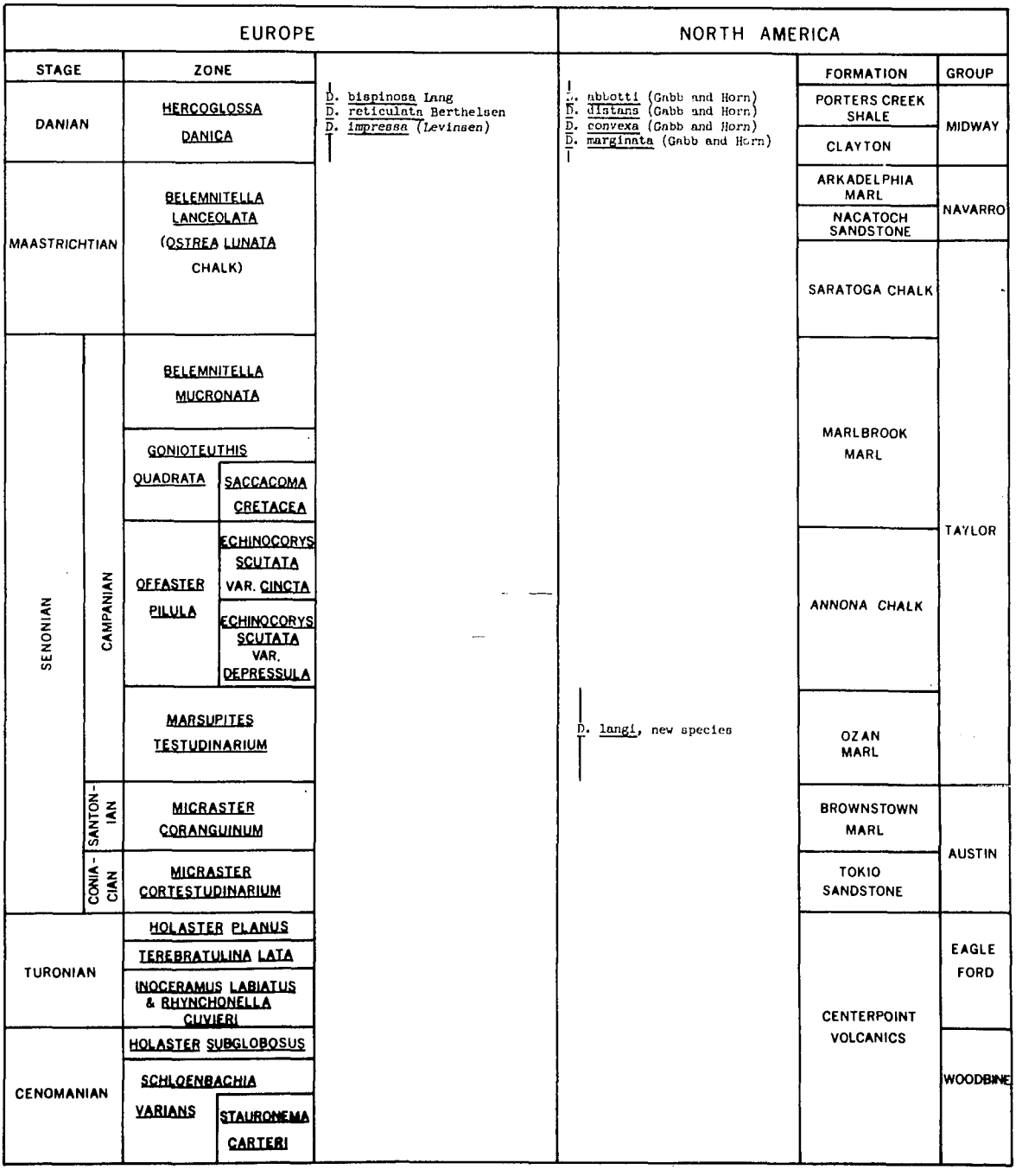
	No.	Mean	Std. Dev.	Observed Range
Lz	5	0.40 mm	0.048 mm	0.35 - 0.45 mm
lz	5	0.25 mm	0.018 mm	0.23 - 0.28 mm
ho	5	0.11 mm	0.014 mm	0.09 - 0.12 mm
lo	5	0.09 mm	0.009 mm	0.08 - 0.11 mm
Lov	1			0.15 mm
lov	1			0.21 mm
Lav	6	0.07 mm	0.009 mm	0.06 - 0.08 mm
lav	6	0.05 mm	0.011 mm	0.03 - 0.06 mm

Occurrence.--Top marl bed of Ozan Formation, immediately underlying the Annona Chalk. Locality AS-5.

Discussion.--D. langi differs from D. reticulata Berthelsen, from the Danian of Denmark, in having larger zooecia with about twice as many costae and in lacking secondary calcification. D. langi differs from D. abbotti (Gabb and Horn), from the Vincentown Marl of New Jersey, in zoarial form and in having smaller zooecia. Other species of this genus from both Europe and North America show greater differences from D. langi than the two species do.

D. langi is the oldest recorded species of Diacanthopora and occurs considerably lower than other species (Figure 16).

Fig. 16. Range chart of species of Diacanthopora


EUROPE
NORTH AMERICA
STAGE
ZONE
FORMATION
GROUP
DANIAN
HERCOGLOSSA DANICA
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
MARSUPITES TESTUDINARIUM
SANTONIAN
MICRASTER CORANGUINUM
CONIACIAN
MICRASTER CORTESTUDINARIUM
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
D. bispinosa Lang
D. reticulata Berthelsen
D. impressa (Levinsen)
D. abbotti (Gabb and Horn)
D. distans (Gabb and Horn)
D. convexa (Gabb and Horn)
D. marginata (Gabb and Horn)
D. langi, new species
PORTERS CREEK SHALE
CLAYTON
MIDWAY
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
MARLBROOK MARL
ANNONA CHALK
OZAN MARL
TAYLOR
BROWNSTOWN MARL
TOKIO SANDSTONE
AUSTIN
CENTERPOINT VOLCANICS
EAGLE FORD
WOODBINE

Suborder Ascophora Levinsen, 1909

Family Hippothoidae Levinsen, 1909

Stictostega, new genus

Etymology.--Gr., *Stiktos*, punctured, and *stegos*, cover; referring to the tremocyst.

Type species.--*Stictostega durhami*, new species, Ozan Formation, Arkansas.

Diagnosis.--Frontal wall calcareous, regularly and uniformly perforated with large, quincuncially arranged pores. Orifice dimorphic in zooecia and gonoecia, broadly sinuate, without peristome or spines. Vibracula interzooecial, small, one placed distally to each zooecium. Gonoecia with distal swelling around orifice which is wider than that of zooecia. Interzooecial communication by dietellae.

Discussion.--This genus is similar to *Trypostega* Levinsen in having perforate frontal, sinuate, dimorphic orifice, interzooecial heterozooecia, gonoecia, and dietellae; however, in *Trypostega* the oral sinus is deeper and set off by lateral condyles, the heterozooecia are kenozooecia rather than vibracula, and the gonoecia have a much larger

distal portion. The genus Hippothoa Lamouroux, with which Trypostega is generally placed in the Family Hippothoidae, differs from Stictostega in having an imperforate frontal and more swollen distal part of gonoecium and in lacking vibracula. Stictostega thus seems to belong to the Family Hippothoidae and to be more closely related to Trypostega than to Hippothoa.

The only species of Stictostega known is S. durhami, from the Ozan Formation, described below. Trypostega is known from species occurring in sediments as old as Paleocene, as well as in Recent seas (Canu and Bassler, 1920, p. 325-327). The range of Hippothoa is given by Bassler (1953, p. G195) as Cretaceous to Recent; Tertiary records of genus are unknown, and the Cretaceous record is apparently a reference to several species described by d'Orbigny (1851, p. 384) as Hippothoa from the Cenomanian of France. At least one of these species, H. laxata d'Orbigny, has been proved to belong to the anascan genus Pyripora (Thomas and Larwood, 1960, p. 373), and, though d'Orbigny's illustrations of them are vague, it seems unlikely that any of them really belong to Hippothoa. Therefore, Stictostega may be regarded as the oldest genus of Hippothoidae and as the probable

ancestor of Trypostega.

Stictostega durhami, new species

Plate 5, figure 6

Etymology.--Named in honor of C. O. Durham, Jr.

Material.--Holotype 8245, Louisiana State University Geology Museum, a zoarial fragment with 76 complete zooecia. Paratype 8272, another zoarial fragment.

Diagnosis.--The only species of Stictostega known.

Description.--Zoarium membraniporiform, incrusting valves of Gryphaea vesicularis, with zooecia arranged in bifurcating rows radiating outward from ancestrula, those zooecia in adjacent rows alternating in position. Interzooecial communication by a few small dietellae on distal and distolateral margins.

Zooecia distinct, separated by deep furrows; ovoid to irregularly hexagonal; about half as wide as long; distal margin angular to broadly rounded; proximal margin sharp or truncate.

Frontal wall strongly convex, doming distally about orifice, finely granular, uniformly perforated with large

pores regularly arranged in quincunx; on a few zooecia, frontal extends completely over orifice, sealing it.

Orifice semicircular, evenly rounded distally, broadly sinuate proximally, without peristome or spines.

Vibracula interzooecial, small, one occurring at distal margin of each zooecium; opening transverse to zooecial axis, asymmetrical, with single condyle on distal margin.

Gonoecium slightly larger than zooecium, with distal swelling and slightly inflated and enlarged orifice.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	9	0.71 mm	0.053 mm	0.64 - 0.77 mm
lz	9	0.42 mm	0.034 mm	0.37 - 0.47 mm
ho	9	0.12 mm	0.025 mm	0.08 - 0.15 mm
lo	9	0.13 mm	0.019 mm	0.12 - 0.15 mm
Lv	6	0.73 mm	0.047 mm	0.67 - 0.79 mm)
lv	6	0.43 mm	0.046 mm	0.37 - 0.50 mm) Gonoecium)
ho	5	0.13 mm	0.026 mm	0.12 - 0.17 mm)
lo	5	0.17 mm	0.020 mm	0.15 - 0.19 mm) Gonoecium)

Occurrence.--Immediately below the Ozan-Annona contact in a marl bed of the Ozan Formation, Taylor Group, at White Cliffs Station. Locality AS-5.

Discussion.--This species does not have a known European counterpart.

Family Porinidae d'Orbigny, 1852

Genus Frurionella Canu and Bassler, 1926

Frurionella Canu and Bassler, 1926, p. 35.

Type species.--Frurionella parvipora Canu and Bassler, 1926, p. 35, pl. 5, figs. 6-18 (by original designation). (Cretaceous Ripley Formation), Tennessee.

Discussion.--Canu and Bassler (1926, p. 35) erected Frurionella for two species from the Ripley Formation of Tennessee with the observation that "the orifices that are elongated and pyriform are opesia narrowed at the point of articulation of the opercular valve . . . (which) is most significant and leaves no doubt as to the true structure of the species, which belongs to the (Anasca) in spite of the resemblance to the Ascophora." Their assignment of Frurionella and the Recent genus Foveolaria Busk (with which they compared it) to the anascan family Calloporidae has been followed by Bassler (1953, p. G160) and other authors. Voigt (1964, p. 436-437), however, after a thorough review

of the problem, concluded that "the aperture of Frurionella is not an opesium, but an orificium," and, therefore, that Frurionella belongs in the Ascophora. Voigt's conclusion has been further substantiated by examination of topotypes of F. parvipora in which openings similar to the "pyriform opesiae narrowed at the point of articulation of the opercular valve," described and illustrated by Canu and Bassler, have proved to be broken ovicells confluent with the circular zooecial orifices.

Comparison of specimens of Frurionella parvipora with Busk's (1884, p. 68, pl. 23, figs. 4-6) illustration of Foveolaria elliptica Busk reveals that the zooecial openings are very different in form in the two genera, Foveolaria exhibiting well-developed cryptocysts within raised mural rims. Actually, Frurionella is more similar to Pachythecella Canu and Bassler. As the type species of the latter genus requires clarification, the relationship between the two may prove to be closer than familial. Tentatively, they may be regarded as separate genera in the family Porinidae.

Frurionella parvipora Canu and Bassler, 1926

Plate 5, figures 3, 5

Frurionella parvipora Canu and Bassler, 1926, p. 35, pl. 5, figs. 6-18.

Material.--Figures specimens 8252 and 8253, Louisiana State University Geology Museum, two zoarial fragments. Many other zoarial fragments were studied but not catalogued.

Diagnosis.--Frurionella having small zooecia lacking mucro.

Description.--Zoarium adeoniform to vinculariiform, slightly compressed to cylindrical in cross section, composed of seven rows of zooecia, those in adjacent rows alternating in position.

Zooecial boundaries indistinct, the frontal walls merging, with only shallow depressions or none left between.

Frontal wall smooth to finely granular, with variable number of scattered pores of varying size; some zooecia with a single, large, median pore proximal to orifice. Pores seem to originate as lateral areolae and to migrate toward frontal midline with increasing calcification.

Orifice small, subcircular to almost semicircular,

distally rounded, proximally rounded to almost straight.

Avicularia adventitious and vicarious. Adventitious avicularium single, placed near frontal midline on proximal border of orifice, transversely to distally directed, rarely missing; rostrum spatulate; pivotal bar present. Vicarious avicularia developed on zooecial margins replacing zooecia in longitudinal rows, about a third as large as zooecia, with large, spatulate rostrum directed distally; pivotal bar complete.

Ovicells not discernible on material at hand.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	10	0.64 mm	0.035 mm	0.60 - 0.71 mm)
lz	10	0.44 mm	0.012 mm	0.41 - 0.46 mm) Measured between zooecial orifices)
ho	9	0.12 mm	0.010 mm	0.10 - 0.13 mm
lo	9	0.15 mm	0.010 mm	0.10 - 0.17 mm
Lav	9	0.19 mm	0.004 mm	0.17 - 0.20 mm)
lav	9	0.18 mm	0.011 mm	0.17 - 0.20 mm) Adventitious avicularia)
Lav	8	0.20 mm	0.007 mm	0.19 - 0.22 mm)
lav	8	0.20 mm	0.010 mm	0.19 - 0.22 mm) Vicarious avicularia

Occurrence.--Six feet below the Nacatoch-Saratoga contact in a marl of the Saratoga Chalk, Taylor Group, in a broad exposure along a roadcut. Locality AHe-1.

Discussion.--Canu and Bassler (1926, p. 35) showed that the ovicells of this species, not discernible externally, are small but hyperstomial, buried by thickening of the frontal. F. grandipora was described by Canu and Bassler (1926, p. 36) as having characters identical to those of F. parvipora except for greater dimensions. As size seems to vary considerably within specimens, the two names may refer to the same species, especially because the two are sympatric at their type locality.

F. polonica Voigt (1964, p. 438), from the Danian of Poland and the Crimea, displays the same size relationship to F. daniensis Berthelsen, from the Danian of Denmark. However, in this case an additional character, the occasional presence of a mucro in F. polonica, permits separation of the two allopatric taxa.

F. parvipora is present in large numbers throughout the Saratoga Chalk; its greatest concentration is in the lowermost unit in an indurated mass of Gryphaea vesicularis fragments.

Frurionella is restricted to Maastrichtian equivalents in the United States, but ranges from Maastrichtian to Danian in Europe (Figure 17).

Family Exochellidae Bassler, 1935

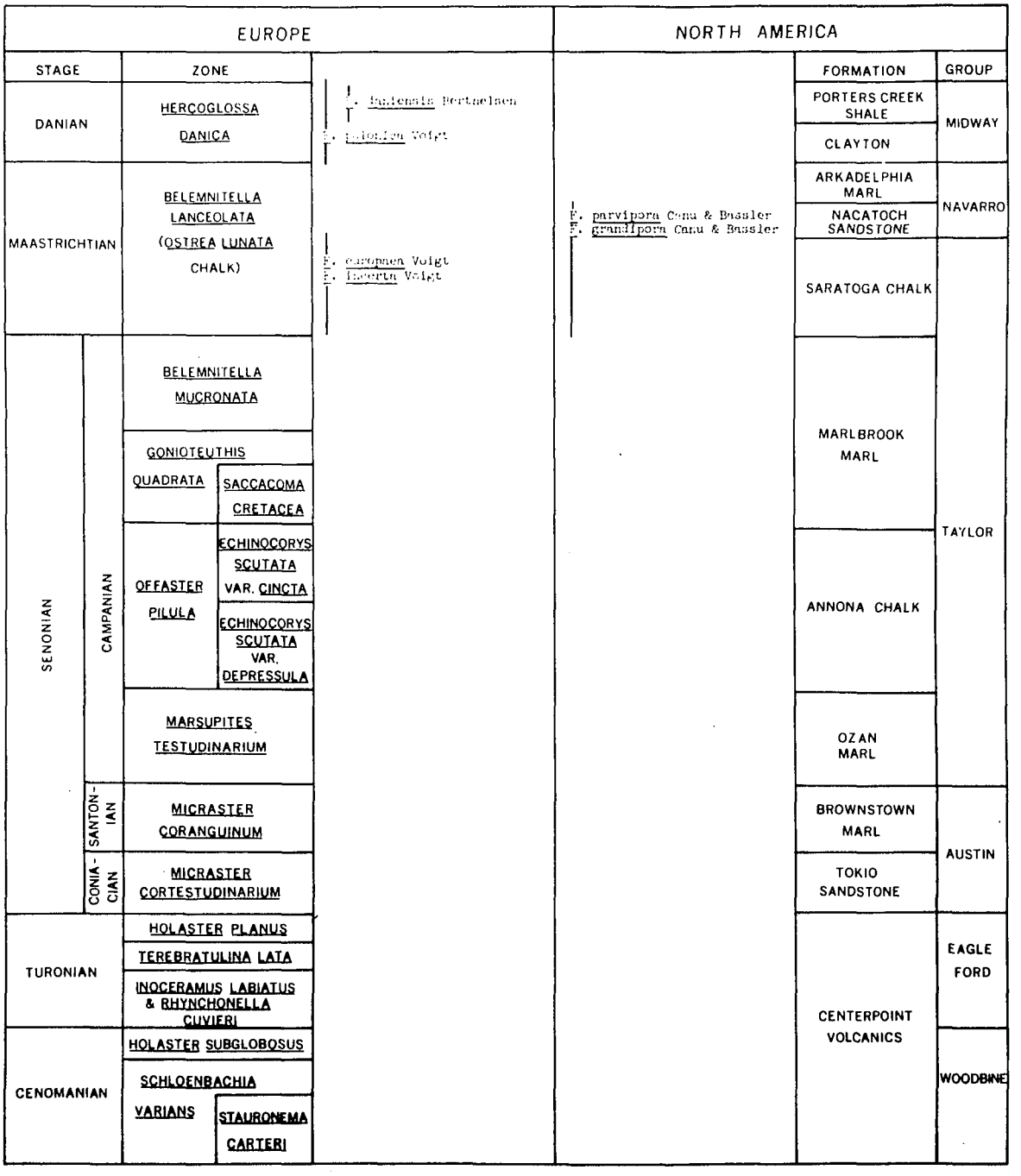
Genus Escharoides Milne Edwards, 1836

Type species.--Cellepora coccinea Abildgaard, 1806, p. 30, pl. 146, figs. 1-2 (chosen by Norman, 1903). Recent; North Sea, Heligoland.

Discussion.--Two European Maastrichtian species and one species from the Vincentown Marl of New Jersey, all having characters similar to three of the Arkansas Gulfian species, have been referred to Exochella Jullien by Canu and Bassler (1933) and Voigt (1962). Jullien (1891, p. 55) erected Exochella for two Recent species, one South Pacific, the other South Atlantic, having the secondary orifice with a median proximal tooth which frequently unites with paired lateral processes to form a round pore at each proximo-lateral corner.

Brown (1952, p. 288-289) questioned the value of the tricuspid proximal lip of the secondary orifice as a criterion for recognizing Exochella, and proposed instead that

Fig. 17. Range chart of species of Frurionella


EUROPE
NORTH AMERICA
STAGE
ZONE
FORMATION
GROUP
DANIAN
HERCOGLOSSA DANICA
F. haslevensis Bertnelsen
F. kalzdorfensis Voigt
PORTERS CREEK SHALE
CLAYTON
MIDWAY
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
F. europaea Voigt
F. laevigata Voigt
F. parvipora Canu & Bassler
F. grandipora Canu & Bassler
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
MARSUPITES TESTUDINARIUM
MARLBROOK MARL
ANNONA CHALK
OZAN MARL
TAYLOR
SANTONIAN
MICRASTER CORANGUINUM
BROWNSTOWN MARL
CONIACIAN
MICRASTER CORTESTUDINARIUM
TOKIO SANDSTONE
AUSTIN
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
CENTERPOINT VOLCANICS
EAGLE FORD
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
WOODBINE

the genus be reserved for species "with convex, marginally-areolated frontal walls bearing paired or single, acuminate lateral avicularia with raised rostra directed laterally." Cheetham and Sandberg (1964, p. 1033), who restudied the two species originally included by Jullien in Exochella, reinstated the tricuspid secondary orifice in the diagnosis of the genus. Escharoides has been characterized (Brown, 1952, p. 288; Cheetham, 1966, p. 65) as having a single median tooth with or without (but not coalescent with) paired lateral teeth in the secondary orifice, a marginally areolate frontal wall, and paired avicularia on or near the peristome directed laterally.

Exochella and Escharoides are very close morphologically. The former is unknown in the Tertiary, whereas the latter is known from several species of Tertiary age (Canu and Bassler, 1920, p. 535; Cheetham, 1966, p. 65). The Cretaceous and Paleocene species from Arkansas, New Jersey, and Europe may be assigned provisionally to Escharoides because of the structure of their secondary orifices, the position of their avicularia, and their stratigraphic position.

The lack of areolar pores in most Cretaceous species may be the result of poor preservation; the well-preserved

specimens of E. septentrionalis (Canu and Bassler) from the Vincentown Formation have small areolae (Canu and Bassler, 1933, p. 79).

Escharoides ? danei, new species

Plate 5, figure 2

Etymology.--Named in honor of Carle H. Dane.

Material.--Holotype 8246. Louisiana State University Geology Museum, a zoarial fragment with 17 complete zooecia and 10 incomplete zooecia.

Diagnosis.--Escharoides (?) having membraniporiform zoarium, zooecia without discernible areolae, oral avicularia rounded and directed outward, and vicarious avicularia; frontal avicularia lacking.

Description.--Zoarium membraniporiform, incrusting valves of Gryphaea vesicularis with zooecia arranged in irregular rows radiating from ancestrula, those zooecia in adjacent rows alternating in position. Interzooecial communication by small dietellae.

Zooecia distinct, separated by a raised thread within a deep depression; about twice as long as wide; rhomboid;

distal and proximal margins rounded; lateral margins slightly curved.

Frontal wall moderately convex rising distally to form a slightly flaring peristome; surface finely granular, imperforate, without discernible areolae.

Primary orifice hidden at base of filled peristome; secondary orifice semicircular, with pointed median proximal mucro and 3-4 distal spines.

Avicularia adventitious and vicarious. Adventitious avicularia paired or single, on proximal margins of peristome, directed transversely laterally; rostrum rounded; opening rounded, with pivotal bar. Vicarious avicularia about half as long as zooecia, with proximal half covered by an imperforate frontal and distal half a spatulate rostrum directed distally; opening pyriform, lacking pivotal structures.

Ovicell hyperstomial, imperforate, finely granular smooth, bulbous; about as wide as long, with orifice opening into peristome.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	8	0.47 mm	0.023 mm	0.45 - 0.51 mm
lz	8	0.25 mm	0.014 mm	0.22 - 0.28 mm
ho	8	0.12 mm	0.008 mm	0.11 - 0.13 mm
lo	8	0.12 mm	0.004 mm	0.11 - 0.13 mm
Lov	8	0.13 mm	0.021 mm	0.11 - 0.15 mm
lov	8	0.15 mm	0.020 mm	0.13 - 0.19 mm
Lav	8	0.11 mm	0.013 mm	0.09 - 0.13 mm) Adventitious)
lav	8	0.11 mm	0.017 mm	0.09 - 0.14 mm) Avicularia)
Lav	6	0.21 mm	0.013 mm	0.15 - 0.19 mm) Vicarious)
lav	6	0.096 mm	0.005 mm	0.09 - 0.10 mm) Avicularia)

Occurrence.--Lowest unit of the Saratoga Chalk in a bed consisting of fragments of Gryphaea vesicularis, at the north edge of Saratoga, Arkansas. Locality AH-1.

Discussion.--This species differs from E. ? eleanorae (Brydone) in having more distally placed, rounded adventitious avicularia directed outward rather than distally; from E. ? nomas, n. sp., in having vicarious avicularia, in lacking frontal avicularia, and in having the oral avicularia directed outward rather than inward; and from E. erymnos, n. sp., in having avicularia directed outward rather than randomly

and in having a salient mucro.

Escharoides ? nomas, new species

Plate 5, figure 1

Etymology.--Gr., nomas, roving; referring to the arrangement of the zooecia.

Material.--Holotype 8247, Louisiana State University Geology Museum, a zoarial fragments with 39 complete zooecia and 31 incomplete zooecia.

Diagnosis.--Escharoides (?) having membraniporiform zoarium, semicircular orifice displaying salient mucro; zooecia without discernible areolae, but with oral avicularia pointed and directed transversely inward; frontal avicularia on proximal part of zooecium; vicarious avicularia lacking.

Description.--Zoarium membraniporiform, incrusting fragments of Exogyra ponderosa, with zooecia arranged in irregular rows radiating from ancestrula. Interzooecial communication by small, elongate dietellae.

Zooecia distinct, separated by a wide furrow; almost as wide as long; rhomboid; proximal and distal margins

broadly rounded.

Frontal wall strongly convex, rising distally to form a peristome, imperforate, smooth, without discernible areolae.

Primary orifice semicircular; distal margin rounded; proximal margin straight or slightly concave. Peristome thick, with well-developed median proximal mucro and 3 or 4 distal spines.

Avicularia adventitious, paired oral and single frontal. Oral avicularia placed at proximo lateral corners of secondary orifice, with acuminate to rounded rostra directed transversely inward. Frontal avicularia placed on proximal margin of frontal wall, one or occasionally two; rostra pointed, directly obliquely distally; pivotal bar complete.

Ovicell hyperstomial, bulbous, imperforate, finely granular, as wide as long; orifice semicircular, with smooth lip opening into peristome.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	8	0.38 mm	0.015 mm	0.36 - 0.41 mm
lz	8	0.35 mm	0.029 mm	0.31 - 0.38 mm
ho	8	0.11 mm	0.012 mm	0.09 - 0.13 mm
lo	8	0.13 mm	0.007 mm	0.12 - 0.13 mm

	No.	Mean	Std. Dev.	Observed Range
Lav	8	0.12 mm	0.012 mm	0.11 - 0.14 mm
lav	8	0.09 mm	0.008 mm	0.08 - 0.11 mm
Lov	7	0.13 mm	0.010 mm	0.12 - 0.14 mm
lov	7	0.15 mm	0.016 mm	0.14 - 0.19 mm

Occurrence.--Lowest unit of the Ozan Formation, immediately above the Brownstown Marl, in a glauconitic, arenaceous limestone. Locality O-1.

Discussion.--This species differs from E. ? eleanorae (Brydone), the widespread species of the European Upper Cretaceous, in lacking vicarious avicularia, in having frontal avicularia, and in having the oral avicularia directed transversely inward rather than distally.

E. ? nomas and E. ? sp. described below occur at a lower stratigraphic position than any described species of Escharoides, though Voigt (1959, p. 705) showed the lower range of the genus (which he included in Exochella) down to the basal Campanian.

Escharoides ? erymnos, new species

Plate 4, figure 5

Etymology.--Gr., Erymnos, fenced, referring to the thread separating zooecia.

Material.--Holotype 8248, Louisiana State University Geology Museum, a zoarial fragment consisting of 59 complete zooecia.

Diagnosis.--Escharoides ? having membraniporiform zoarium, zooecia without discernible areolae and with poorly developed mucro, and single, small, randomly oriented avicularium; vicarious and frontal avicularia lacking.

Description.--Zoarium membraniporiform, incrusting valves of Gryphaea vesicularis with zooecial arranged in irregular bifurcating and trifurcating rows radiating from ancestrula, those zooecia in adjacent rows alternating in position. Interzooecial communication by large, elongate dietellae, three at distal and distolateral margins.

Zooecia distinct, separated by salient, wide thread rising from deep furrow; hexagonal; about two-thirds as wide as long; distal and proximal margins straight or angular; lateral margins angular to broadly rounded. Frontal wall strongly convex, attaining greatest height distally where it forms a peristome about orifice; surface smooth and imperforate, without discernible areolae.

Orifice terminal on frontal surface, surrounded by a low peristome; secondary orifice circular to semicircular

with poorly-developed mucro and without distal spines.

Avicularium adventitious, single, raised, placed on peristome near distal lateral margin; beak blunt, randomly oriented; with pivotal bar lacking.

Ovicell broad, flat, longer than wide; imperforate, finely granular.

Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	8	0.45 mm	0.027 mm	0.41 - 0.48 mm
lz	8	0.28 mm	0.022 mm	0.26 - 0.32 mm
ho	8	0.16 mm	0.012 mm	0.15 - 0.19 mm
lo	8	0.13 mm	0.009 mm	0.12 - 0.14 mm
Lov	3	0.12 mm	0.029 mm	0.08 - 0.13 mm
lov	3	0.15 mm	0.047 mm	0.14 - 0.15 mm
Lav	8	0.11 mm	0.013 mm	0.09 - 0.13 mm
lav	8	0.08 mm	0.022 mm	0.07 - 0.13 mm

Occurrence.--Seven feet below the base of the Annona Chalk in the Ozan Formation in a shell hash of Gryphaea vesicularis and Gryphaea convexa. Locality AS-5.

Discussion.--This species differs from E. ? najdini (Voigt), from the lower Maastrichtian of the Crimea, in having salient, wide interzooecial threads, larger zooecia, smaller mucro, and smaller avicularium.

Escharoides ? sp.

Plate 5, figure 4

Material.--Figured specimen 8249, Louisiana State University Geology Museum, a zoarial fragment with 10 complete zooecia.

Diagnosis.--Escharoides (?) having membraniporiform zoarium, zooecia with very small marginal areolae and a well-developed, anvil-shaped mucro; avicularia and ovicells lacking.

Description.--Zoarium membraniporiform, incrusting valves of Exogyra ponderosa; zooecia arranged in rows radiating from ancestrula, those zooecia in adjacent rows alternating in position. Interzooecial communication by small dietellae and a single, large, distal septulum.

Zooecia distinct, separated by deep furrows; irregularly hexagonal; almost as wide as long; proximal and distal margins rounded; lateral margins broadly rounded.

Frontal wall strongly convex, highest distally; smooth, imperforate, with a marginal row of very small areolae; an irregular, superficial, granular layer occurs on proximal and lateral margins of some zooecia.

Orifice subterminal, subcircular to oval, with proximal, well-developed, anvil-shaped mucro, but without

distinct peristome; distal margin with 6-8 large spine bases.

Avicularia and ovicells lacking.

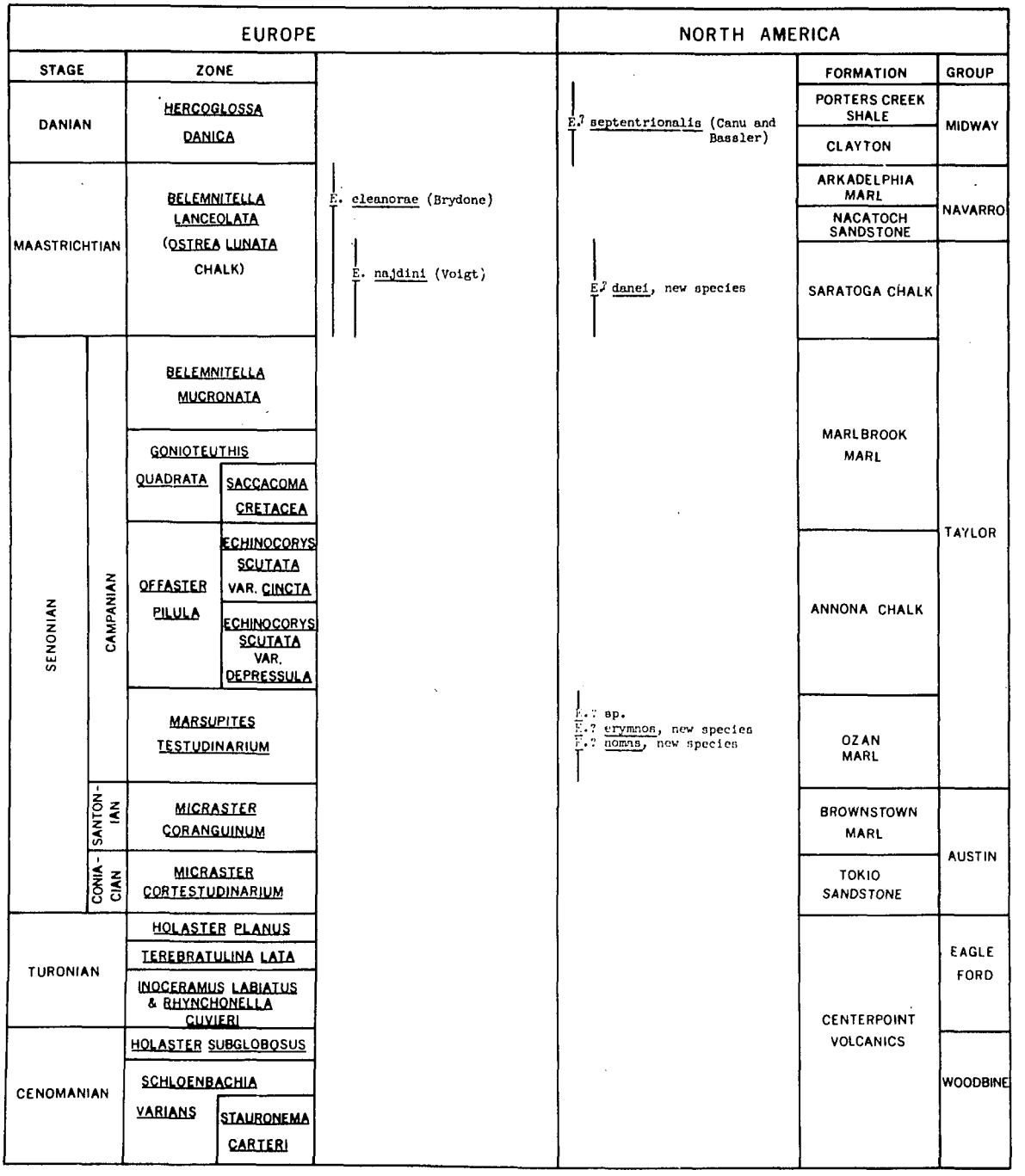
Measurements.--

	No.	Mean	Std. Dev.	Observed Range
Lz	8	0.32 mm	0.017 mm	0.30 - 0.35 mm
lz	8	0.26 mm	0.023 mm	0.23 - 0.30 mm
ho	8	0.10 mm	0.012 mm	0.08 - 0.12 mm
lo	8	0.10 mm	0.009 mm	0.08 - 0.11 mm

Occurrence.--Lowest unit of the Ozan Formation, immediately overlying the Brownstown Marl, in a glauconitic, sandy limestone. Locality O-1.

Discussion.--Though the single specimen of this species seems distinct from others, the few immature zooecia, lacking avicularia and ovicells, are insufficient on which to found a new taxon.

Fig. 18. Range chart of species of Escharoides (?)


EUROPE
NORTH AMERICA
STAGE
ZONE
FORMATION
GROUP
DANIAN
HERCOGLOSSA DANICA
MAASTRICHTIAN
BELEMNITELLA LANCEOLATA (OSTREA LUNATA CHALK)
SENONIAN
CAMPANIAN
BELEMNITELLA MUCRONATA
GONIOTEUTHIS QUADRATA
SACCACOMA CRETACEA
OFFASTER PILULA
ECHINOCORYS SCUTATA VAR. CINCTA
ECHINOCORYS SCUTATA VAR. DEPRESSULA
MARSUPITES TESTUDINARIUM
SANTONIAN
MICRASTER CORANGUINUM
CONIACIAN
MICRASTER CORTESTUDINARIUM
TURONIAN
HOLASTER PLANUS
TEREBRATULINA LATA
INOCERAMUS LABIATUS & RHYNCHONELLA CUVIERI
CENOMANIAN
HOLASTER SUBGLOBOSUS
SCHLOENBACHIA VARIANS
STAURONEMA CARTERI
E. cleanorae (Brydone)
E. najdini (Voigt)
E.? septentrionalis (Canu and Bassler)
E.? danei, new species
E.? sp.
E.? erymnos, new species
E.? nomas, new species
PORTERS CREEK SHALE
CLAYTON
MIDWAY
ARKADELPHIA MARL
NACATOCH SANDSTONE
NAVARRO
SARATOGA CHALK
MARLBROOK MARL
ANNONA CHALK
OZAN MARL
TAYLOR
BROWNSTOWN MARL
TOKIO SANDSTONE
AUSTIN
CENTERPOINT VOLCANICS
EAGLE FORD
WOODBINE

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REGISTER OF LOCALITIES

Clark County

AC-1 High Bluff, 1.5 miles north of Arkadelphia, on the Ouachita River, in the SE¼, Sect. 8, T. 7 S., R. 19 W., exposing the Nacatoch and Saratoga formations.

AC-2 Roadcut exposing the Arkadelphia-Nacatoch contact, 5th Street, by Missouri Pacific Railway Station, in the SE¼, Sect. 17, T. 7 S., R. 19 W.

AC-3 Roadcut, 8.1 miles northwest of Arkadelphia on Hwy. 8, in the W ½ of Sect. 7, T. 7 S., R. 20 W., exposing the Brownstown Marl.

AC-4 East bank of Little Missouri River, in the SW ¼, Sect. 36, T. 9 S., R. 22 W., exposing the Nacatoch Sandstone.

AC-5 Roadcut, 7.8 miles west of Arkadelphia, SE¼, Sect. 30, T. 7 S., R. 20 W., exposing the Saratoga Chalk.

AC-6 Gullied hills in SE¼, NE¼, Sect. 29, T. 8 S., R. 21 W., exposing the Saratoga Chalk.

Hempstead County

AHe-1 Roadcut, exposing Saratoga-Marlbrook Contact, in the SW¼, Sect. 5, T. 12 S., R. 27 W., one mile southwest of Saratoga.

AHe-2 Roadcut in the SW ¼, Sect. 30, T. 10 S., R. 24 W., exposing the Marlbrook Marl.

AHe-3 Roadcut, three miles northeast of Washington in the NE¼, Sect. 14, T. 11 S., R. 25 W., exposing the Nacatoch Sandstone.

AHe-4 Railroad cut, one-half mile west of McNab, in the SE¼, Sect. 36, T. 12 S., R. 27 W., exposing the Nacatoch Sandstone.

AHe-5 Roadcut on Hwy. 355, 2.7 miles north of Fulton, in the NE ¼, Sect. 7, T. 13 S., R. 36 W., exposing the Arkadelphia Formation.

AHe-6 Roadcut in the SW¼ of NW¼ of Sect. 16, T. 12 S., R. 23 W., exposing the Arkadelphia Formation.

AHe-7 Roadcut on Hwy. 4, six miles northwest of Hope, in the NE ¼, Sect. 2, T. 12 S., R. 25 W., exposing the Arkadelphia Formation.

Howard County

AH-1 Roadcut on Hwy. 55, north edge of Saratoga, in the SE¼, Sect. 32, T. 11 S., R. 27 W. (Type locality of the Saratoga Chalk).

AH-2 Roadcut on Hwy. 55, one-half mile north of Saratoga, in the SE¼, of NE¼, Sect. 32, T. 11 S., R. 27 W., exposing the Marlbrook Marl.

AH-3 Quarry at Okay, in the SW¼, Sect. 30, T. 11 S., R. 27 W., exposing the Annona Chalk.

AH-4 Roadcut, 3.5 miles south of Mineral Springs, on Hwy. 55, in the NW¼, Sect. 33, T. 10 S., R. 27 W., exposing the Ozan Formation.

Little River County

ALR-1 Roadcut on Hwy. 32, 5.6 miles west of Foreman, Arkansas, in the W. ½ of Sect. 18, T. 12 S., R. 32 S., exposing the Ozan Formation.

ALR-2 Roadcut and quarry 1.7 miles southwest of Foreman, on Hwy. 108, in the SE¼ of the SW¼, Sect. 29, T. 12 S., R. 32 W., exposing the Annona Chalk.

Sevier County

AS-1 Roadcut, one mile southwest of Rosedale, in the

NE¼ of the SE¼, Sect. 23, T. 9 S., R. 29 W., exposing the Centerpoint Volcanics.

AS-2 Roadcut, one mile north of Ben Lomond, near the center of Sect. 32, T. 10 S., R. 29 W., exposing the Tokio Sandstone.

AS-3 Roadcut, 1.5 miles southeast of Ben Lomond, in the SE¼ of NW¼, Sect. 15, T. 11 S., R. 29 W., exposing the Brownstown and Buckrange formations.

AS-4 Quarry at White Cliffs Station in the NE¼, Sect. 35, T. 11 S., R. 29 W., exposing the Annona Chalk.

AS-5 Rivercut at White Cliffs Station on Little River, in the NE¼, Sect. 35, T. 11 S., R. 29 W., exposing the Ozan-Annona contact.

Oklahoma

O-1 Roadcut, 1.1 miles west of Arkansas-Oklahoma state line, McCurtain Co., Hwy. 21, SW¼, SW¼, SW¼, Sect. 28, T. 9 S., R. 27 E., exposing the Ozan-Brownstown formations.

EXPLANATION OF PLATE I

All figures X 75.

FIG. 1--*Alderina inuber*, n. sp. LSU holotype 8234, 13 zooecia, one at upper left showing dietellae.

2--*Pyripora brownstownensis*, n. sp. Two zoaria; LSU holotype 8232, right zoarium with three zooecia; LSU paratype 8254, upper left zoarium with two zooecia.

3--*Solenophragma* sp. LSU 8238, zoarium with small interzooecial avicularia and four complete zooecia.

4--*Ramphonotus pedunculatus*, n. sp. LSU holotype 8235, 35 zooecia with pedunculate adventitious avicularia.

PLATE I

EXPLANATION OF PLATE II

All figures X 75.

FIG. 1--*Dionella vivistratensis*, n. sp. LSU holotype 8239, zooecia showing scars of hyperstomial ovicells and gymnocysts with small pores.

2--*Solenophragma elongatum*, n. sp. LSU holotype 8236, zooecia with interzooecial spaces reduced to triangular openings.

3--*Solenophragma ovatum* (Canu and Bassler). LSU 8250, zooecia with large avicularia occupying most of the interzooecial spaces.

4--*Dionella racemata*, n. sp. LSU 8240, zooecia with numerous distally-directed interzooecial avicularia.

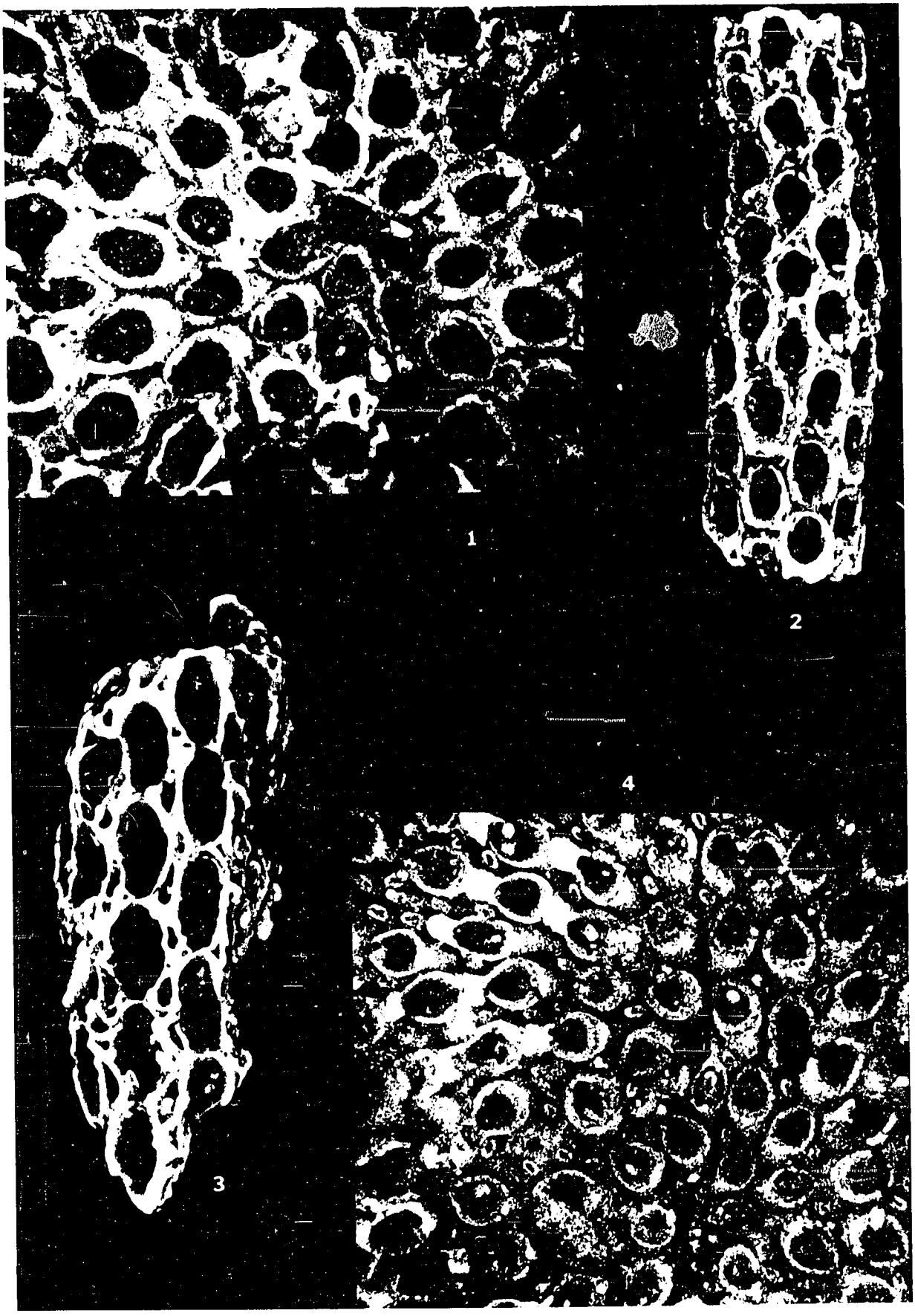

PLATE II

EXPLANATION OF PLATE III

All figures X 75.

FIG. 1--*Ellisina saratogaensis*, n. sp. LSU 8233, zooecia exhibiting small, transverse, interzooecial avicularium distal to each zooecium.

2--*Aechmella ozanensis*, n. sp. LSU 8241, zooecia with three vicarious avicularia.

3--*Micropora* ? sp. LSU 8251, zooecia showing septules. All cryptocysts are broken.

4--*Cheethamia howei*, n. gen., n. sp. LSU 8237, zooecia with vicarious avicularia.

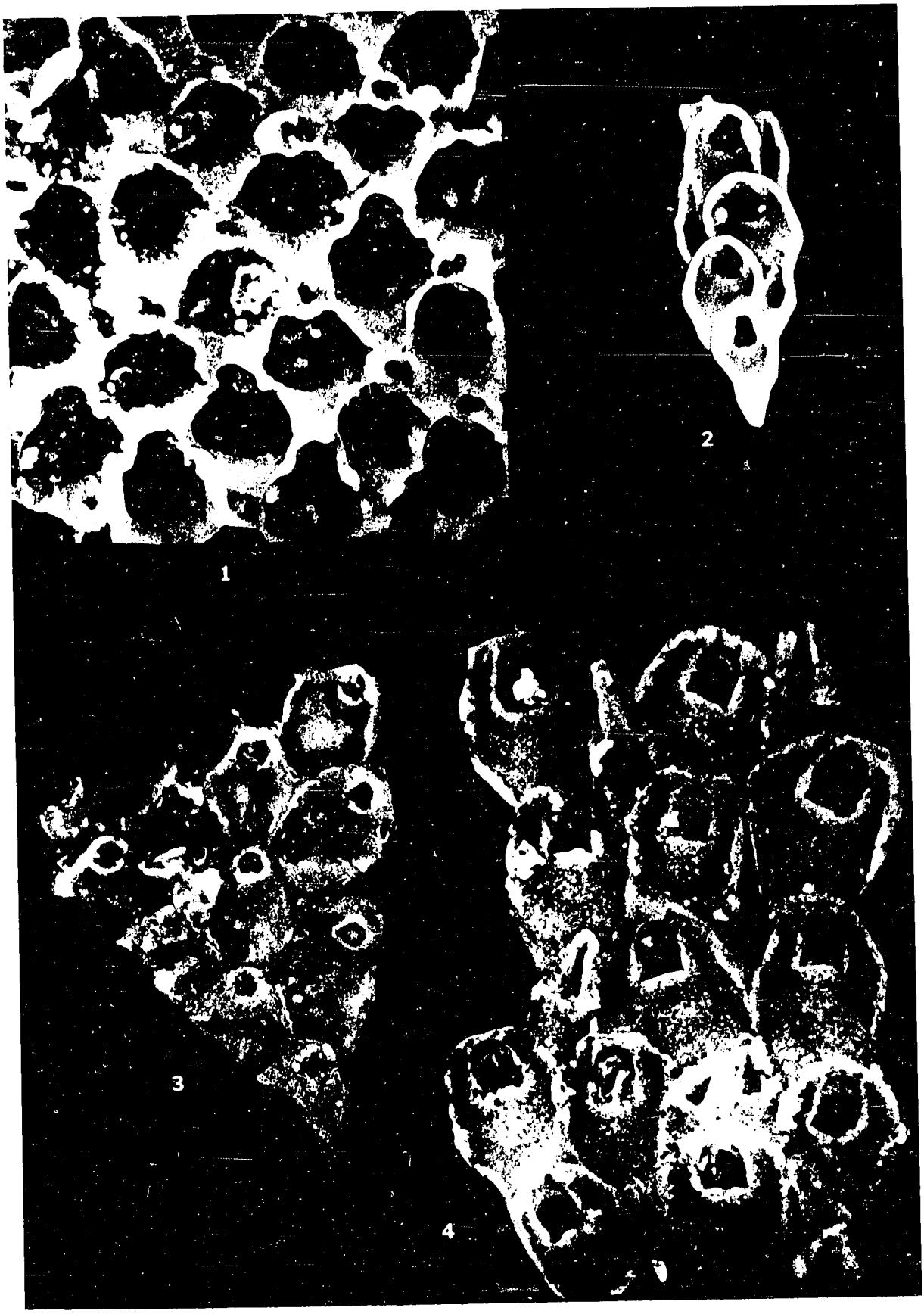

PLATE III

EXPLANATION OF PLATE IV

All figures X 75.

FIG. 1--Castanopora spooneri (Butler and Cheetham). LSU 8273, zoarium with small, monomorphic, distally-directed avicularia and four complete hyperstomial ovicells.

2--Tricephalopora larwoodi, n. sp. LSU 8242, zooecia with regularly paired, lateral-oral avicularia directed inward.

3--Diacanthopora langi, n. sp. LSU 8244, zoarium with one complete hyperstomial ovicell.

4--Tricephalopora arkansasensis, n. sp. LSU 8243, zooecia with avicularium lateral on gymnocyst, lapping onto peristome of laterally adjacent zooecium.

5--Escharoides ? erymnos, n. sp. LSU 8248, zoarium with 17 zooecia. One small avicularium at upper left.

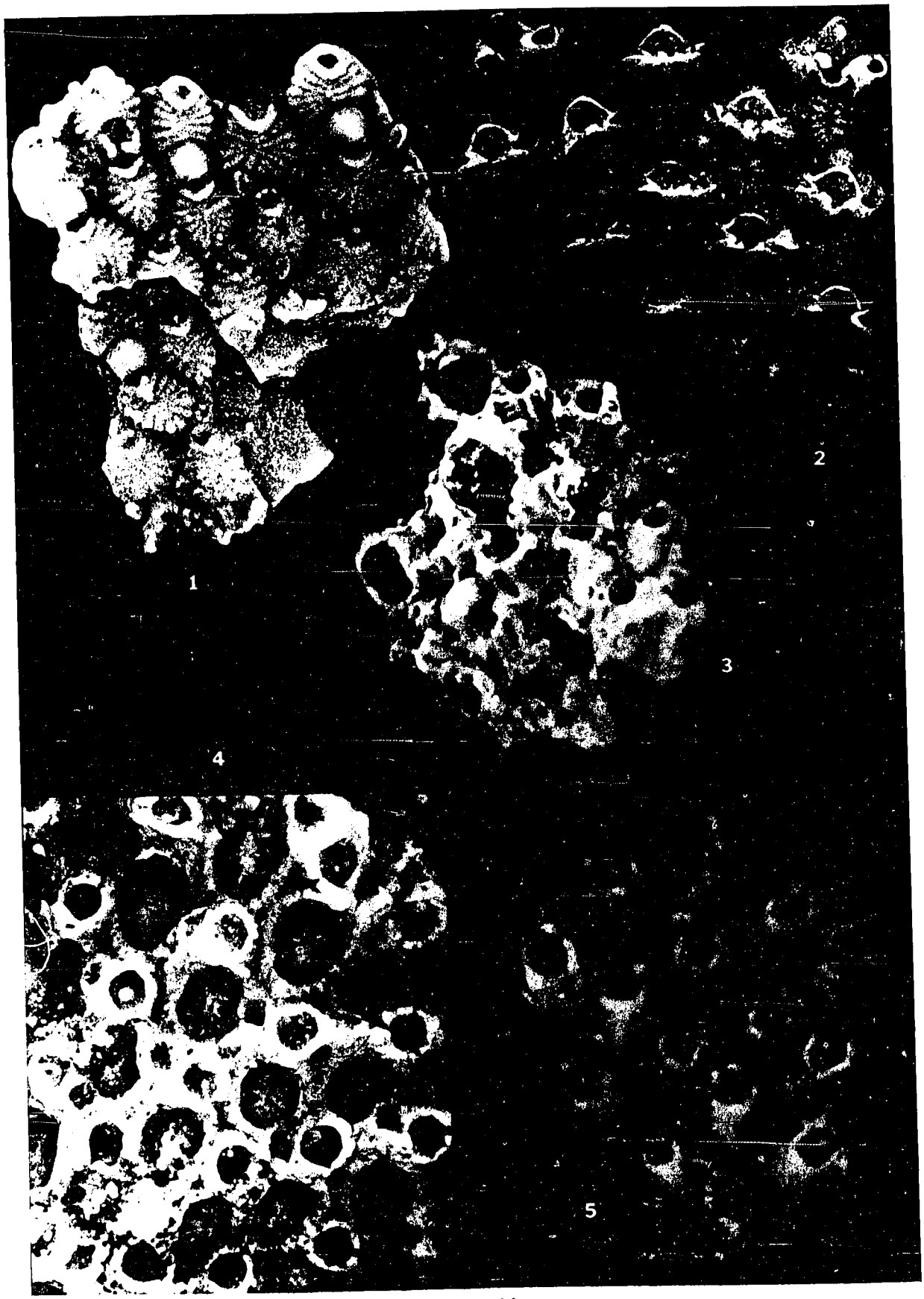

PLATE IV

EXPLANATION OF PLATE V

All figures X 75

FIG. 1--*Escharoides ? nomas*, n. sp. LSU 8247, zoarium with five complete hyperstomial ovicells and zooecia with avicularia directed transversely inward.

2--*Escharoides ? danei*, n. sp. LSU 8246, zoarium with numerous hyperstomial ovicells.

3--*Frurionella parvipora* Canu and Bassler. LSU 8252, zoarium cylindrical.

4--*Escharoides ? sp.* LSU 8249, zoarium with 10 zooecia showing anvil-shaped mucro. Oral spines on zooecium at far left.

5--*Frurionella parvipora* Canu and Bassler. LSU 8253, zoarium slightly compressed.

6--*Stictostega durhami*, n. gen., n. sp. LSU 8245, zoarium with vibracula placed distal to each zooecium.

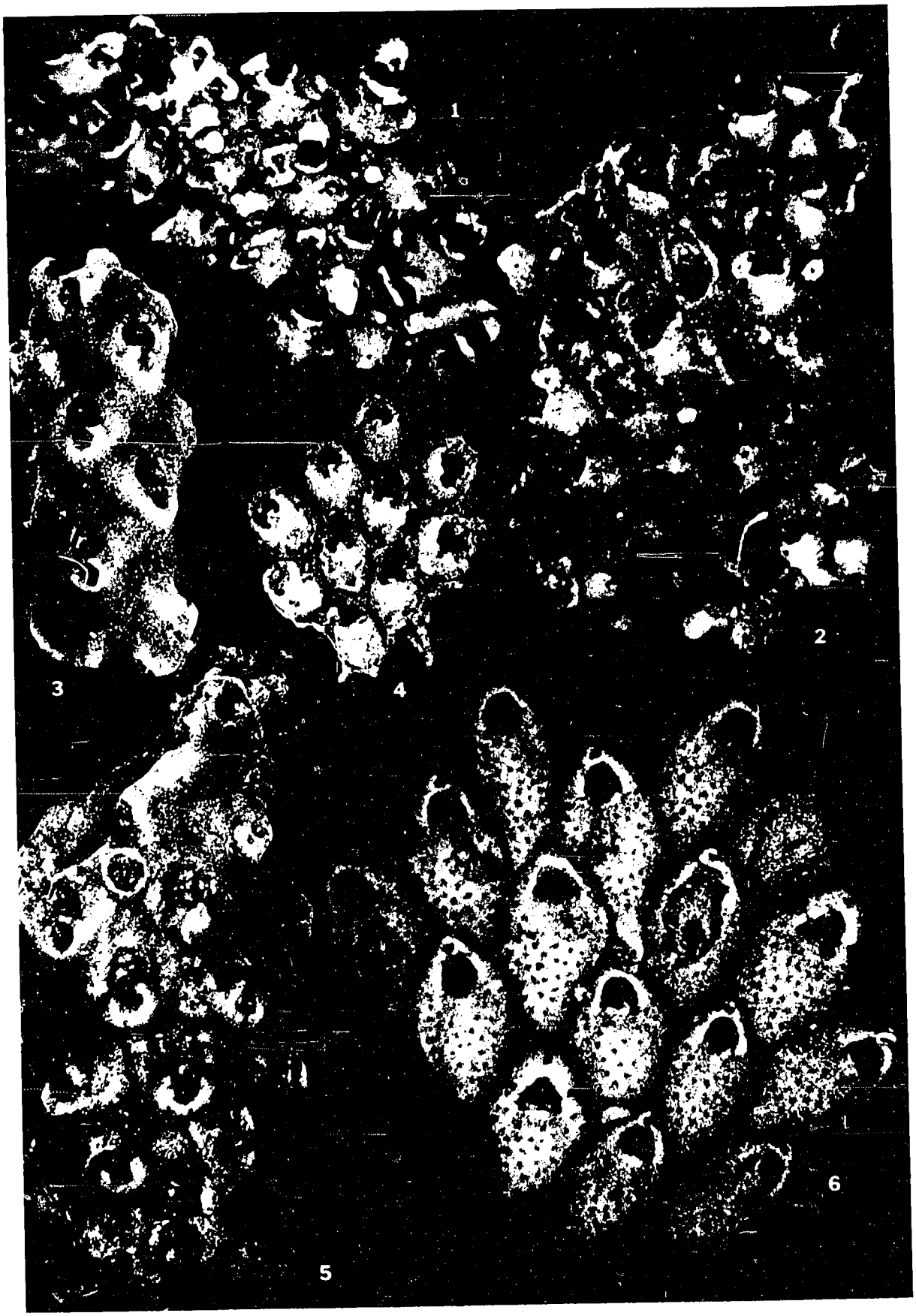

PLATE V

VITA

Nolan Gail Shaw was born in Forsan, Texas, on October 2, 1929, the son of Bertha Irene and Ivy Odell Shaw. He attended public schools in Forsan, Monahans, and Wink, Texas, and graduated from high school in 1946. He entered Decatur Junior College in 1946 and received the AA degree in 1948. In September, 1948 he entered Baylor University and received the AB degree in 1951 and a commission with the United States Air Force. In September 1951, he entered SMU and after one year his education was interrupted by the Air Force. He received the MS degree from SMU in 1956. In September 1955 he was employed by Centenary College.

In September 1959 he entered LSU as a candidate for the Ph.D and is a candidate for graduation in January, 1967. Since 1961 he has been employed by Centenary College, Shreveport, Louisiana.

EXAMINATION AND THESIS REPORT

Candidate: Nolan Gail Shaw

Major Field: Geology (Paleontology)

Title of Thesis: Cheilostomata of the Gulfian Cretaceous of Southwestern Arkansas

Approved:

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

August 12, 1966